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THEORIES OF BIRD MIGRATION.

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Migratory Route of the American Golden Plover

The American Golden Plover is known to travel in the neighborhood of 15,000 miles a year. Its breeding grounds are well within the arctic circle far beyond the northern tree line. In fact Gen. Greeley, the arctic explorer, found it nesting at 81° N. latitude within 600 miles of the north pole. These remarkable birds arrive in the far north about June 1st, remaining there approximately ten weeks. By the latter part of August, nesting duties completed, they have already traveled as far south as Labrador where a rich temporary feeding ground supplies them while the crowberries, common to that region, are ripening. From Labrador they move further south to Nova Scotia, and thence straight out over the open ocean 1,800 miles to the islands that lie east of Cuba and Porto Rico, sometimes breaking the journey at the Bermudas 800 miles south of Nova Scotia but more frequently passing by to the eastward. From the Eastern Antilles to the continent of South America is a flight of 600 miles more and after this mainland is reached they press on to the pampas region of Patagonia where they remain for the winter months, 8,000 miles from their nesting grounds. March finds them on the move again as far north as Guatemala and Texas. During April they are traversing the Mississippi valley, in May the vast territory of Canada, while early in June they are nest-building again in the land of the midnight sun, having completed the 15,000 mile circuit.

What explanation can be given to account for such astonishing behavior? How is a bird, who weighs only a few ounces and whose brain can easily be packed in a thimble, able to find its way over such vast reaches of land and sea, and what are the laws which impel it to carry out such a colossal undertaking in the face of all sorts of perils, not only once in a lifetime but every year so

long as it lives? The American Golden Plover is an extreme case, but the laws which govern its behavior are doubtless the same as those which cause the lesser, but quite as noteworthy, migratory movements so generally observed among bird kind.

Early Mention of Migration The migrations of birds have been recognized by man from the earliest times. Mention is made in the book of Job of the hawk that "stretches her wings toward the south." Homer observed the mighty rush of the water fowl northward in the spring and Anacreon, in classic lines, welcomed the returning swallow five centuries before Christ.

Schlegel Serious attempts to ascertain the facts of migration in any detail have been attempted only within the last century. For instance in 1828 Schlegel of Haarlem made an analysis of the accounts of travelers in various lands upon 130 different journeys. After compiling all references which these travelers made to the birds which they saw he concluded from these heterogeneous statistics that, for any given locality, birds might be divided into three groups; first, *residents,* who remain all the year in one locality; second, *erratic wanderers,* who appear irregularly, and third, *migrants,* who pass through the locality at regular times. Since Schlegel's time there has followed many years of faunistic work by various observers who have catalogued the birds known to occur in different localities. This extremely useful kind of work is still being done in both hemispheres, since, until the general distribution of birds is more accurately known mere speculation upon their movements is productive of few results.

von Middendorf In 1855 von Middendorf of St. Petersburg combined all the faunistic data then available in an attempt to find out the manner of bird movements by means of what he termed isopeptic lines. The isopeptic lines were arbitrarily formed by connecting the points of first arrival of certain species over as large an area as possible for any one date. By constructing a series of such isopeptic lines upon the map of Russia for succeeding dates he obtained a graphic representation of the kind of advance made during migration, throughout that region, drawing therefrom the general conclusion that birds move forward during migration in a broad front. Furthermore, the direction of the main European migration routes he determined theoretically by extending lines at right angles to the isopeptic lines.

Sundevall and Peters

It soon came to be seen, however, that only general results could be hoped for so long as particular instances were not known. The first attempt to obtain detailed data concerning the movements of any single species of birds was the outcome of a correspondence about the migration of storks begun during 1862 between Sundevall in Sweden and Peters in Berlin. These two naturalists called upon their colleagues to aid them in making observations at various localities. Thus in a short time a large amount of data was collected concerning the migratory movements of storks, a species particularly favorable for study by reason of their being so conspicuous and everywhere well known. As the result of this collaboration, the migratory route of the stork in Europe has been established with considerable acuracy.

Palmen

The efforts of Sundevall and Peters were followed in 1876 by the masterly work of Palmén of Sweden who determined the migratory route of nineteen species of European birds. Palmén emphasized the fact that birds do not travel in a "broad front" as suggested by von Middendorf but that instead each species moves in a definite path or route of its own.

Cooke

About 25 years ago the U. S. Biological Survey began a systematic collection of data concerning the movements of migratory birds in North America and already several most valuable papers, based upon the abundant data thus being collected, have appeared from the pen of Mr. W. W. Cooke, who is in charge of these admirable investigations.

Meanwhile speculations have multiplied far in advance of facts. It goes without saying that satisfactory explanations of the laws governing bird migration can only be hoped for after a far greater basis of facts has been established. However, speculations and theories of bird movements, unsatisfactory as they are, possess a certain interest, not to say value, as indicating the progress of science along this line of investigation. These guesses at the truth may accordingly be grouped as the answers to two questions: first, how do birds find their way in migration, and second, why do birds migrate?

I. How do Birds Find Their Way in Migration?

Instinct Theory

To say that birds find their way instinctively is only a roundabout method of acknowledging that we do not know what the mechanism of migration is. The

term "instinct" is a vague generalization which, being made to apply to many diverse phenomena, loses its value in any particular case. Moreover the instinct theory not only does not explain anything but, since it does not admit of experimental test, closes the door upon the hope of ever reaching a satisfactory explanation of the phenomena to which it is applied.

Magnetism Theory In 1855 von Middendorf, to whom reference has already been made, advanced the novel theory that birds are guided by lines of terrestrial magnetism which cross in the body after some such fashion as in a solenoid. This speculation is interesting because there is no known fact whatever in support of it. There are, however, facts against it. In North America, for example, birds do not go toward the magnetic pole as they appeared to von Middendorf to do in Russia. So far as I am aware there is among plants and animals no known case of response in any way to magnetic force.

Semi-circular Canal Theory The attempt to locate some organ within the bird to which this function of path-finding might be referable resulted in the Mach-Breuer theory of the semicircular canals which was elaborated particularly to explain how the carrier pigeon finds its way home. This theory rests upon the supposition that the semi-circular canals of the inner ear form an organ of equilibration by means of which an animal can orient itself in any of the three planes of space. Each of these three canals, which are situated at right angles to each other, enlarges at one of its ends into an ampulla, within which, surrounded by endolymphatic fluid, are located delicate nerve endings coming from the eighth cranial nerve. In whatever position the ear is held the endolymphatic fluid within the semi-circular canals presses more upon the nerve endings within one ampulla than upon those of the other two, and the particular stimulation thus received, upon being transferred to the brain, records for the animal its position in space. Along with this sensory registry of positions in space it is assumed that there has been developed the ability to record intervals of time upon the brain automatically. It is interesting in this connection to notice that the recognition of time intervals is a basic principle of music and birds are notably muscal. Besles a registry of position in space an of time intervals there may be developed a registry of the distance traversed in case a uniform speed is manitained. Thus when a pigeon going away from home travels at a given speed, for example, east twenty min-

utes, north thirty minutes and east again ten minutes, all these changes in direction, together with the time occupied in making them and consequently the distance traveled in following each direction, are recorded upon the brain as sounds are recorded upon the cylinder of a phonograph. To accomplish the return journey it is only necessary to reverse the record made upon the brain in order to get back to the starting point.

A theory of this kind has the advantage of being capable of experiments to test its soundness, and such a test was made in 1893 by Professor Sigmund Exner in Vienna. Exner attempted to find experimentally whether the brain of the carrier pigeon records automatically the direction and distance taken in the outward journey in such a way as to be equipped to make the journey home. He first took two covered cages of pigeons several miles away from home to a locality unknown to the birds and out of sight of all familiar landmarks. During the journey one cage, which was suspended on a wire, was rotated hundreds of times at every point where the direction of the route was changed, while the other cage, containing control pigeons, was borne with great care in order to introduce as little confusion in the stimuli received by the semi-circular canals as possible. When released at the journey's end one at a time so that they could receive no aid from seeing each other, Exner found that, out of the entire number, the first pigeon to arrive home was one that had been whirled! In further experiments Exner produced galvanic dizziness in half of his pigeons during the outward journey by means of a portable dry battery with which he repeatedly sent a slight galvanic shock through the ears. This operation causes a dizziness which is referable to a failure in the semi-circular canals properly to function. Thus in the case of his "galvanized" pigeons the semi-circular canals had been unable to make records with any completeness during the outward journey but, notwithstanding the fact, such pigeons found their way home as quickly as the control individuals which had not been so treated.

Finally, Exner narcotized pigeons in order to destroy their power of recording stimuli, with similar results. He accordingly concluded it is impossible so to confuse the sensory impressions received by a carrier pigeon upon its outward journey as to interfere with its ability to find its way home. Therefore, although the semi-circular canals undoubtedly assist very largely in equilibration and orientation as a mechanism to guide the homing pigeon they

are inadequate and, taken alone, they certainly cannot account for the much more extensive journeyings of migrating birds.

Sense of Direction Theory Certain investigators have attempted to attribute to migrating birds a sixth sense, namely of direction, without going into embarrassing details as to what the physical basis of such a supposed sense might be. It has been repeatedly noticed that animals other than birds have an apparent sense of direction. Everyone can tell, either from experience or hearsay, the uncanny way in which a cat, tied securely in a bag and taken ten miles away and deserted, is found on the doorstep waiting to be let in when its unappreciating master returns home. But seriously after all the discounts rendered necessary by the accounts of the nature fakirs have been made, there remains in the behavior of animals a considerable residue of fact which seems to have its only explanation in the assumption of a sense of direction.

An instance is given by members of the Harriman Expedition in Alaska of the remarkable flight of murres in a dense fog between Unalaska island and their feeding ground upon another island about 60 miles away. These birds were seen repeatedly looming up in the fog behind the steamer then passing on ahead out of sight, flying as steadily and surely as if by compass although it was possible to see hardly more than a boat's length ahead. Such cases strengthen the conviction of many that there must be present in birds an unknown sense which serves them in some such way as the compass serves the mariner. This view, however, is hardly better than the instinct theory since it gives the answer to the problem in unknown terms.

The Landmark Theory The landmark theory has rather more to recommend it. Exner came to the conclusion that carrier pigeons find their way home by seeing familiar landmarks and when such landmarks are not visible the birds explore until landmarks are found. This explains how his pigeons, whether whirled, galvanized or narcotized, were quite as well able to get home as those which had not undergone such interference with their sensory impressions upon the outward journey. Anyone who has observed swallows hawking for insects upon a summer afternoon or who has seen a hawk swoop down upon a field mouse from a dizzy height in the sky, must be convinced that the sight of birds is very acute. This is proven not only by their behavior but by anatomical evidence as well. The eye of the hawk is perhaps the most perfect optical instrument in nature. So far as the

sense of sight goes it may be admitted that birds are well endowed to observe landmarks from a distance, while those birds that habitually migrate during the twilight, as nighthawks, bitterns, woodcock and certain sandpipers, being accustomed to feed at this time of day, have no difficulty in seeing objects in semi-light.

The objection must be raised to the landmark theory, however, that many birds do not follow river valleys, coast lines or mountain chains in the way they might be expected to do if they were guided by what appear to us to be the most obvious landmarks. Furthermore, migratory birds leave Cuba for Florida without hesitation upon cloudy nights when no landmarks are possibly visible and the stretch across the Gulf of Mexico, which is also regularly traversed by birds, is so great that even if migrants rose to a height of five miles, which is beyond reason, they could scarcely see one third of the way across to the other shore on account of the curvature of the earth. Sight alone, then, although it is an important factor, cannot be the only resource of the migratory bird.

The Follow-the-Leader Theory

Still another theory with a large element of probability in it may be briefly described as follows. Birds are social animals and fly in company with each other. The total migratory stream is a vast straggling army, spreading out or narrowing according to the character of the country over which it is passing. Dispersion over a wide area is the surest method of finding the way for in this manner a larger area of landmarks is visible to the migrating flocks. According to the best vantage point of vision, temporary leaders are continually created whom the others may follow. It is well known that when the leader in a harrow of wild geese becomes disabled the others are, for a time at least, thrown into confusion, showing that they were keeping to the path by following a leader. While certain species fly in comparatively close array, as cowbirds for example, others may be straggling far behind the pioneers so that all the members of any one species may occupy over a month in passing a given point. Thus it is possible for any individual bird to have companions constantly to guide it on its way when it might be unable to proceed independently. It is not necessary, however, to assume that the same birds are always the leaders in the flight or that the leaders themselves depend upon landmarks which they can see. It seems reasonable to believe that sound serves to keep the individuals of migrating hosts in communication with each other when sight fails for it is comomnly observed that bird-calls during mi-

gration are much more frequent upon foggy than upon clear nights.

In the case of carrier pigeons the successful individuals are those who have been trained over the course, that is, those who have learned the way either by seeing landmarks for themselves or by following a trained companion. There is no mysterious sixth sense of direction, no crossing of imaginary magnetic lines, no intricate automatic registry of distance and direction by means of the semi-circular canals. It is simply a case of a home-loving animal away from home putting its wits and senses and experiences together to get back to its home and in this case these known resources are sufficient for the task. Why may not this also be the true explanation of the manner in which birds find their way on those greater pilgrimages which we call migration? The murres flying in the fog, the migrants striking out from Cuba for invisible Florida or across the Gulf of Mexico toward an unseen shore, are all either traveling a course they have learned by experience or following within sight or call of others who know where to go. It does not seem any more impossible that a bird should learn to travel a familiar distance without landmarks than that a blind man is able to walk in a familiar path. What causes the migration movement is another problem entirely but, once given the incentive for this wonderful exodus, it seems reasonable to believe that the manner in which it is carried out, the way in which the path is followed, may find an adequate explanation in the temporary leadership of some individual within sight or hearing of the others, who knows at least a fraction of the way by experience or who strikes out a safe path by means of landmarks.

Finally, it must be remembered that all who start upon this winged crusade do not reach the holy land. The annual loss of bird life during migration is unquestionably enormous. Birds are not driven by an unfailing instinct that carries them all automatically to their destination. The blunderers and the stupid ones are relentlessly eliminated in countless numbers. The more resourceful ones, the quicker witted, the more vigilant, accomplish the grand tour amid perils innumerable with many a hair-breadth escape and the survivors are those choice spirits who, having thus won their spurs by noble effort, or because they possess the birthright of a superior endowment over their fellows, become the ancestors of other birds. So it is that winning qualities are engrafted upon the race by hereditary transmission. It is to be greatly wonderel at that, after ages of such rigid selection, we

should at last have birds to-day whose performance is so remarkable that we are tempted to attribute it to powers uncanny and unknown?

II. Why Do Birds Migrate?

Theories to Account for the Fall Migration

Having discussed some of the theories advanced in explanation of how birds find their way during migration let us consider some of the reasons which have been given to solve the origin of the migration habit. Why do birds migrate at all? At once it is seen that the fall migration seems to present fewer difficulties than the spring migration.

The Temperature Theory

It has been maintained by some investigators that the approach of cold weather causes birds to go south in the fall and it is quite true that if all birds attempted to remain in northern latitudes during the winter many would doubtless succumb to the cold. The main factor in such a disaster, however, would not in all probability be low temperature in itself but rather scarcity of food dependent upon low temperature during the winter months. The fact that there are repeated instances of birds, such as robins, song sparrows, etc., which ordinarily migrate south, remaining occasionally in their summer habitat throughout the entire winter, demonstrates that these birds are able to endure low temperature when they have a plentiful food supply. In this connection two well known facts are significant. First, the ordinary bodily temperature of a bird is always several degrees warmer than in the case of man, and secondly, the fall migration begins and is largely completed before the weather becomes cold.

The Premonition Theory

Years ago Brehm attempted to account for the fall migration by assuming that birds have premonitions of severe weather, or in other words that they are endowed in some mysterious way with a meteorological sense. This theory, which at first thought seems entirely fanciful, in reality contains a large element of probability but not exactly in the way that Brehm intended. Birds with their large lungs, pneumatic bones and numerous internal air sacs, are, to a remarkable degree, living barometers, responding with great delicacy to changes in barometric pressure. The uneasy behavior of robins and the repeated calls of cuckoos before a storm are familiar illustrations of this fact. That birds can anticipate winter, however, and as a result make an effort to avoid its disastrous effects, is beyond demonstration and seems quite unlikely.

The Short Day Theory Another alternative has been suggested, namely, that toward the fall of the year the days become too short for the bird to complete its daily task of feeding When the enormous activity of birds is brought to mind and one remembers how rarely a resting bird is seen, particularly among seed and insect eaters, the hardship resulting from shortened working hours can be readily appreciated. The migration south, however, begins before the days are perceptibly shorter and so this theory suffers, as does many another, because of a few obtrusive incontrovertible facts!

The Food Supply Theory Still other theorists have assumed that the factor of greatest importance in causing the fall migration is a diminished food supply but here again it must be admitted that a large per cent. of migrating species leave for the south in the very height of the seed and insect harvest. It may be pointed out, however, that upon the ground of food supply, natural selection would promptly eliminate those who did not go south and would tend at the same time to favor the perpetuation of those who varied in the direction of southern migratory habits, whatever the cause of those variations might be.

Theories to Account for the Spring Migration Turning now to the spring migration, the factor of food supply seems to be of much less immediate importance since in many cases birds, as for instance the water fowl, push their way out of a land of plenty into a region of scarcity.

The Instinct Theory That it is a bird's *instinct* to go north in the spring is no better an explanation of the origin of migration than it is of how a bird finds its way during migration.

(*To be continued.*)

THE FIRST LESSONS IN PHYSICS.[1]

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There has been of late much criticism of current methods of teaching physics. It is said that there is a failure to inspire interest, to inculcate a sound knowledge of principles, and to cultivate the faculty of exact reasoning. It seems quite possible that some of this criticism is undeserved—that many teachers throughout the country may quietly be doing successful work in accordance with their own individual methods, and that the results achieved may bear a fair comparison with those obtained in the teaching of mathematics, the languages, and other subjects. Even if results are not on the average as good as we might hope for, all the blame should not be laid on the teachers, who must be on the average better prepared and not less capable and conscientious, than they were a generation ago. It may be that the pupils themselves should share the blame. A generation ago high school pupils were a picked class, who desired an education for its own sake. Now it is the fashion for all to go to the high school, for very diverse reasons. The inevitable result is a lowering of the average attainments.

But, whatever the state of affairs may be, it seems likely that the study of physics may be made more fruitful by a modification of our present methods which, so far as I can judge from personal observation and reports, seem to be in many cases a mongrel cross between the old method of learning by rote from a text-book and modern laboratory methods carried to an extreme. Some efforts have been made to improve conditions, but they appear to have for their end not a radical change of method, but rather the selection (by popular ballot, to secure the verdict of an inspired democracy) of the "essential" quantitative laboratory experiments, and the rewriting of text-books, flavored with various spices to disguise the natural taste and stimulate the jaded appetite of the student. It is difficult to see how any great improvement can result from such efforts. It seems to me that it matters little what particular experiments a pupil performs, so long as they illustrate some fundamental principle; what is needed is to find some way to make him realize what they mean. Nor is there

[1] Read before the Pacific Coast Association of Chemistry and Physics Teachers, July 27, 1907.

any special need of new text-books; there are a number which are quite good enough. What is really essential is a teacher independent of text-books who can teach the pupil to read directly the "book of nature," to use a trite term.

In order that any subject may be successfully taught the teacher must have a clear conception of the ends to be accomplished. It is to be feared that many of us undertake our work in a rather perfunctory way. We teach physics because it is a part of the conventional curriculum and because we are paid to teach it. The first thing that a teacher should do is to carefully consider the various benefits that may arise from the study of the subject he teaches, to coordinate these ends in the order of their importance, and to lay most emphasis on the most important. Let us consider some of the objects which may be assigned for the study of physics.

1. Preparation for the university. This does not need special consideration; that preparation which will do the pupil most good, if his education ends at the high school, will best qualify him for the university.

2. Accuracy and neatness, skill in manipulation; these are useful habits, but they are probably better learned from drawing and manual training. As subordinate ends they should receive due attention, but they are by no means the primary objects of the study of physics.

3. Practical applications. A very small percentage of those studying in our high schools enter technical pursuits where their knowledge of physics may be practically applied. Even if all did, it would be impossible to teach applications before principles, or to teach both thoroughly in one year. Whenever practical applications can be used to illustrate principles it should be done, but to teach them empirically and to call it education is absurd.

4. The cultivation of a certain directed observational power, sympathetic understanding of natural phenomena, appreciation of the aims and uses of scientific inquiry, and cultivation of the imagination. These are well worth while, and physics offers exceptional opportunities for cultivating these faculties.

5. Acquirement of the scientific method of thought, which I understand to be the mastery of the inductive method in the establishment of principles from self-acquired data, and of the deductive method in applying these principles.

6. The desire to get at the truth without prejudice; independence of traditional authority; efficiency. The ethical value of

scientific training has not been sufficiently emphasized. If pupils make an object of looking for true relations they will unconsciously acquire truthful habits. If they learn to think for themselves on scientific matters they can more easily take an independent attitude in politics, for example. If they acquire the habit of applying scientific rules of evidence they will take a wholesome attitude toward "legal" rules of evidence and the quibbles that so often defeat the ends of justice. If they come to appreciate the importance and possibility of efficiency in material machines they will acquire a distaste for the inefficiency of "machine" government.

There is no reason why regard should not be paid to all these ends; but who can deny that the last three are more important and more to be emphasized than the first three? A general cry is that our high schools should in teaching physics and other subjects "prepare for life," but those who utter this seductive cry usually fail to offer a specific program to show what they mean. Most of us probably believe that all the ends which may properly be considered as preparation for life are included in the above list.

The agencies which contribute to the learning of physics may be classified as follows:

1. The personal observations and experiences of the pupil in his daily life.
2. Qualitative experiments performed before the class by the teacher.
3. Individual quantitative experiments.
4. Text-book and problem work.
5. Exposition by the teacher.

It appears that in most cases the third and fourth agencies are almost exclusively used—in fact, I know of several cases where the third alone was used by enthusiastic advocates of the "inductive" method, with results that were fearful to contemplate. This I believe to be radically wrong, and to involve the sacrifice of what is best worth while in studying physics. All seem to agree that, whatever may be the ultimate ends, the pupil should as far as possible acquire his data at first hand from nature or the laboratory and to drawn his own inferences, and that he should become familiar with the main principles on the basis of his own first-hand knowledge. Does it not distract him from the main object when at the very beginning his attention is focused on numerical results which are certain in his eyes to become the ends in

view, to have the innumerable physical phenomena of daily life pass unheeded while he is memorizing his lesson from the text?

It is of course unreasonable to expect any one, no matter how mature in judgment, to establish for himself, by a course of inductive reasoning, the whole body of principles of a science, or even any one of them; but I believe that the habit of inductive reasoning may be acquired by a proper order of presentation; and I also firmly believe that the prevailing method is absolutely inconsistent with inductive principles. In those schools where this method is most loudly proclaimed we find pupils plunged into quantitative work without any idea of what is expected of them. They make measurements and calculations, and the only definite idea to guide them is that a certain numerical result (neatly written up) is expected. If by some chance they get a hint of the physical principle involved it is because of previous suggestion from books or otherwise; or if the glimmering of a principle occurs to a bright young mind it certainly cannot be called the fruit of inductive reasoning, for as a rule only one quantitative experiment per principle is allowed—"no two must illustrate the same principle," in the words of a recent official proclamation. What sort of inductive method is that which would establish a general principle on one experiment, crudely performed by a beginner? Then, from this extreme application of the "scientific" method, the pupil passes into the recitation room and recites the "theory" from the text book. He glibly describes from memory phenomena which he has never seen—and it would be hard to name any phenomenon suitable for discussion in an elementary course which he could not and ought not to see for himself. No wonder so many young people are disgusted with physics; no wonder that it seems to have accomplished so little in developing mental power. To have a pupil begin the subject with a quantitative experiment seems as absurd and unreasonable as to begin his language study with classical philology or his geography with the determination of latitude and longitude.

Is it not self-evident that if the pupil is to make independent use of his own powers of observation and of reasoning he should have the opportunity to see and judge for himself? If we expect him to make a sound application of the inductive method we must not allow him to reason from insufficient or second-hand information; we must not allow him to believe that the collection of scanty numerical data or the measurement of certain magnitudes gives

him command of basic principles. We must not allow him to lean upon the text-book (or the teacher) as a source of information, or, with all due respect to the cultivation of neatness and accuracy, to look upon accurate numerical results or a neat note-book as the principal objects of his study. When we consider the rich fund of physical phenomena of which the average student remains ignorant while he is engaged in the drudgery of measuring things, one is almost tempted to consider the elementary quantitative laboratory as a curse. Phenomena of daily life and qualitative experiments performed by the teacher or the pupil are as valid material for inductive reasoning as can be found. If children are to learn and to use the inductive method, they must repeat the experience of the human race. They must acquire familiarity with a number of natural phenomena, recognize their analogies and differences, adopt provisional hypotheses, elaborate theories, to such an extent as limitations of time and maturity allow. The very last step of all (and not the first, as many of our physical pedagogues claim), should be the exact numerical statement of relations.

How are these results to be obtained in practice? The following seems to be a logical plan: First of all, the teacher should, in taking up a given subject, get the pupil to recall and describe in his own language the familiar phenomena of daily life which illustrate the principle. Any inferences which he may be able to make should be drawn out. The teacher should then, either alone, or with the help of the pupils, perform before the class a large number of illustrative qualitative experiments, all the while encouraging the class to draw conclusions. In this way the foundations of the general principle may be laid in strict accordance with inductive methods. The next step would be for the pupil to perform some qualitative experiments to give him the more vivid impression of direct contact and some manipulative skill; and finally, in some cases, a few quantitative experiments to impress upon him the invariable relationships involved in physical changes. After this should come class-room discussions and recitations based entirely on the direct personal experience of the pupils—it is easy enough to furnish abundant material of this sort. Last of all, the pupil may read his text to get supplementary information, definite data regarding constants, perspective, and historical background. No one can deny the usefulness of a good text book; but it should be used in the same way that a catalogue is used in an art gallery. In that case all would agree that the pictures, not the catalogue,

are the primary objects of attention; in studying a science, natural phenomena should be the immediate objects of our study. In reading I believe that more attention should be given to such general works as those of Tyndall, which arouse interest and stimulate the imagination; to the historical development of the science and the biographies of the great scientists, which supply human interest. Put more of such books and fewer text books in the school library.

To make the suggested plan more clear by a concrete example, suppose that the subject is the relation between heat and changes of state. Often the first step is to send the pupil into the laboratory to find the heat of fusion of ice. The pupil usually has one clear idea—that he must by some device find the number 80—dynes, ergs, centimeters, calories, or something. He usually succeeds in getting that number, and finds from the text-book that the interpretation is that 80 calories (whatever that may be) have been absorbed in the change of state. He is then ready to inform the teacher on demand that 80 calories will melt a gram of ice, or paraffin, or anything else. He has made no comparisons, and has no reason to believe that different substances will behave differently. If he gets any accurate ideas at all it is certainly not by any process of induction. But suppose that the teacher first gets him to recall the effect of fanning, the cooling of water by placing it in a porous vessel, the method of finding the direction of the wind by holding up a moistened finger, and other things of this sort. It will be easy for the average pupil to arrive at the induction, with very little suggestion, that there is some relation between the evaporation and the cooling in each case. Then on the lecture table show the freezing of water by the evaporation of ether, the constancy of temperature of melting ice, paraffin, and other solids, and of boiling water and other liquids, and also the changes of temperature accompanying solution. The usual paucity of experiments leads many pupils to believe that water alone is subject to changes of state. After this, it will not be difficult for the pupil to clearly recognize that heat is absorbed or evolved in any change of state—absorbed in the disintegrative processes, evolved in the integrative processes. This idea may be very clear and definite; no greater fallacy has befogged the teaching of elementary physics than the belief that there can be no clear ideas unless they are expressed in numerical terms. After the principle has been firmly grasped, and not before, the pupil may profitably perform

some quantitative experiments to show that definite quantities of energy are involved in any change of state. All this will give him abundant data for recitation and problem work without memorizing the details of a text-book.

It may be urged that there are practical difficulties in carrying out such a program. There are some, undoubtedly, but they are probably not so serious as may be supposed. Adequate use has not been made of the phenomena of daily life, nor of simple class-room demonstrations. A little glass tubing, bottles, rubber tubing, tin cans, wire, a few cheap lenses, home-made galvanometers and electroscopes, will furnish material for all the available time, at a nominal expense. The main demand for equipment is that of the teacher himself. We are so frozen up in the conventions of physics teaching that we fail to see and use familiar natural phenomena; we do not realize what may be accomplished with simple means; we come to believe that principles do not apply except to experiments performed with elaborate apparatus made in Germany; we believe that all that is worth while in physics is expressed in numbers only.

The most serious obstacle, provided a teacher of insight and resource is available, is adequate time for preparation. It requires patient thought to develop an effective series of topics and experiments; it takes time to set up the simplest apparatus. But if the best results are to be achieved, our educational authorities must see to it that our teachers are not overwhelmed with too many subjects or too many pupils in the same subject.

To sum up, it is my opinion that it is not wise to use a text-book in beginning the study of physics, because the pupil will consider that the book, not physical phenomena, is the object of his study; that a large amount of quantitative work is to be avoided, particularly before the principle it is designed to illustrate is well established by the observation of a number of examples, because it gives a false emphasis to the numerical results rather than to the underlying principles, because it makes progress too slow, because it involves an amount of drudgery incommensurate with the results, and above all, because it does not conform to the logical order of induction. I believe that the backbone of an elementary course should be the experience of the pupil and an abundance of qualitative class experiments, to be discussed until their full significance is brought out; that reading references should be sparingly given, mainly for historical details and for information

not readily obtained by direct observation. I think that by teaching the subject in this manner the study of physics may be made far more interesting and far more effective than by the methods apparently now prevalent.

STRUCTURE OF HAILSTONES.

By Cleveland Abbe,

Monthly Weather Review, March, 1906.

There are three plausible hypotheses as to the origin of the snowy ice at the center of a hailstone.

(a) The hailstone may have begun with the formation of a ball of snow, and the clear ice may be a deposit of cold water, frozen a few seconds later by the cold of the surrounding atmosphere. In this case the air that is mixed with the snowy ice at the center would be compressed by the freezing of the surrounding clear ice, and would be liberated as a bubble when the hailstone is melted under water.

(*b*) The nucleus of the hailstone may have been at first a large drop of water, containing dissolved air, which is forced out by the process of freezing, precisely like the bubbles of air that are seen in cakes of artificial ice. Cold water can dissolve an appreciable percentage of its volume of air, all of which is extruded when water freezes; a bubble of highly compressed air might thus be formed at the center of the hailstone. If such a hailstone be melted in cold water slowly, all of this air will be redissolved, and no bubble will be seen to rise to the surface. If the stone be dissoved in hot water rapidly, or especially if the stone be crushed forcibly and quickly under water, the air may escape as a bubble without having had time to be redissolved.

(*c*) A hailstone formed of pure water that has had no opportunity to absorb or dissolve air can be reduced to a temperature far below freezing, but will eventually suddenly turn to ice, at which moment its temperature will rise to 32° F., and it will assume a crystalline structure, so as to resemble snow. Such a hailstone has, therefore, a snowy nucleus without any inclosed air, and on being melted under water will, of course, show no bubble. In fact, the central space is occupied, not by air, but by the vapor of water only, and as the pressure is very small, we may liken this to a partial vacuum.

All these three forms of hailstones, and other forms as yet unthought of, are possible; and if we could invent methods of distinguishing between these three kinds of hailstones, we should have a better knowledge of what goes on in the upper air during the formation of hail.

Those who have proper conveniences will find that the study of hailstones under polarized light gives additional information as to their crystalline structure, but has not as yet told us much about the process of formation.

As ice is a poor conductor of heat, it is worth while to make some effort to determine the temperature of the interior of a large hailstone. The external surface may safely be assumed to have the temperature of evaporation or the average wet-bulb temperature prevailing in the lower thousand feet of air through which the hail has rapidly fallen, but the center must be at a temperature more nearly corresponding to that at which the nucleus was formed. There is, therefore, a state of strain that should be revealed by polarized light. The average temperature of the whole hailstone may be easily and directly determined by allowing hail to melt within a calorimeter, where the heat consumed can be determined, and then the temperature be computed.

Before making such researches on hailstones, we must devise methods of catching them that will prevent injury or warming or even melting by reason of the shock that occurs when the hail strikes the hard ground. Probably it would be sufficient to catch the hail in the "bag gage for hail," described in the *Monthly Weather Review* for September, 1897, Vol. XXV, p. 210, or on a bed of soft cotton, or in a barrel half full of water. Pieces of strong cloth or paper spread on water will catch a large hailstone nicely, the momentum of the hail carries the cloth downward and it is quickly wrapped about the hail.

THE INTERRELATION OF PHYSIOLOGY AND MORPHOLOGY.

By Earl E. Ramsey,

High and Manual Training School, Ft. Wayne, Ind.

When this topic was assigned me for discussion, I first sought a reason for giving time to such a topic. With a moment's thought the reason is very apparent. For our secondary school work the explanation lies in the too often deplorable condition of the teaching—and of the ones taught as well—of physiology, morphology, and other closely related subjects. There are those who will not agree with me on this general proposition and it is granted at the outset that this is but one side of the story, but this side is too demoralizing to the work to go unnoticed. Accepting truth as either an absolute or a relative principle, the fact that much of the work done is strong and vital doesn't make the unacceptable work any more acceptable. When the work in biology is improved upon, it will be after the shortcomings in the teachings of biology are understood and candidly admitted.

Note the following cases gathered at random and judge of the situation for yourself. Not all are from school work, but all are from people who have been closely connected with schools and the contact has, to say the least, left some very ludicrous ideas. A minister in a sermon I heard a while ago attempted to illustrate one of his statements that beauty and truth cannot be reached through the process of analysis and classification. He attempted to illustrate his statement by the use of an ox-eye daisy taken from the pulpit bouquet. He held the flower aloft and with great gusto plucked the—he called them petals—from the head and as they fell in a shower to the floor, he announced that there was now nothing left but the pistil and that the beauty was all gone. It is needless to say that the illustration went flat. A teacher told her class that the thumb joint is a ball and socket joint. Another told her classes that a model of a blood clot, standing out on the base on a model of an apoplectic brain, was a ganglion. A nature study teacher held a grasshopper up before her classes and told them of its gizzard. And then from the profundity of her ignorance she said, "You know we all have gizzards, children."

Lest the purpose of these illustrations be misunderstood, let me say that I do not want to make something horrible

out of a matter of misinformation or out of a matter of insufficient observation about a gizzard of a grasshopper, or of that still more wonderful organ, "our gizzard," or a thumb joint, or a pistil or a ray. That these are bad is not any considerable part of my contention, though it is a part of it. The trouble lies in the probability that such statements emanate from a storehouse of material of the same ilk as those cited. There is no interest either native or acquired shown by any of those cited. There can be no appreciation, there is no foundation for appreciation. There is either a lack of any real observation or what is even worse, through inaccuracy of observation. The examples further show what a part of the mental heritage of those cited has been; what the heritage of the boys and girls of to-day is; and what the heritage of the future is.

All these considerations point to a need for better work along the lines of morphology and physiology and naturally raise the question as to what the causes of this unfavorable condition are, and as to what the remedies are. An answer to these points will naturally involve a discussion of the purposes of morphology and physiology.

There is still extant a notion that science is training first, last and always. It does not, the advocates of this idea say, make any difference how much ground one covers; covering ground for the purpose of collecting material is not a legitimate aim. Discipline the mind, is their word. Now disciplining the mind of a boy who is not well grounded on the informational side of a science presents the spectacle of two baseball nines battling for supremacy, but without either ball or bat. They strike, run, slide, are put out, root, whip the umpire, abuse each other and yet there is no game. The beauty of the game consists in the heady way in which the ball and bat are handled. Give the student something that can be skillfully handled. The game of thinking consists in handling facts skillfully and truthfully. The end may be largely discipliniary, but the means to the end is a knowledge of the subject. Despise not the means.

Unless this complex of discipline and fact be accepted as a working basis, the too little noticed correlative value of physiology and morphology is very largely lost. Each phase has a definite aim within itself, but a higher value comes in the fact that each becomes a key with which the other may be unlocked and a light wherewith to explore it. The real property of no

science is fenced off as are our lots and farms. They overlap. So the real wonder is that the sequences have been so little noted, or what is probably a more accurate statement, that this relation is so little used. This sequence is no less true of the peculiar strain of training derived from these sciences than it is of the logical train of facts. Correlation has been subjected to much criticism and ridicule through the zeal of its votaries and rightly so; but too little attention has been given to the correlation of structure and function. Herein lies the first proposed remedy for the occasional existence of unfruitful work,

Now as to the ways in which morphology can aid in physiology. Strangely enough, laboratory practice in physiology has not developed apace with that in either morphology, physics or chemistry. Physiology with physiography forms the rear guard in the procession. When one considers the purposes of the subject and its possibilities because of the marked development of laboratory morphology, this seems less explainable. What has been done in even elementary physiology? We have read the text-books when a question arose; not often have we made any observations of physiological activity or performed any experiments leading to any conclusions respecting physiology. That the gastric juice acts on proteids is accepted as a bare, bald fact; that it actually does do so not one class in ten has ever given the opportunity of proving or of seeing proven. That the heart pumps blood, that the mitrals and tricuspids prevent the re-entrance of blood into the auricles, that the semilunars on both sides prevent the re-entrance of blood into the ventricles; all are taken as true. Even that there is an auricle is a matter of text with many teachers and most students. What the auricle looks like is a matter of imagination to many. As to where it is many teachers are in doubt when a real "flesh and blood" heart, and not a manikin is shown them. What a vast deal more of interest, information and well grounded faith could have been developed by the teacher's having secured a heart, making the proper attachments to the various heart vessels by means of glass tubes, using blue litmus solution for venous blood and acidifying the blue litmus in that part of the apparatus corresponding to the pulmonary circulation to secure red blood and then causing the heart to beat artificially by means of hand pressure. Undeniable relation of structure and function are thus presented to the student. We must break away from the text-book and turn to

such lines of work if any life is to be instilled into our students.

But there is a distinct change setting in. To the recent college and university graduates who have turned to the profession of teaching with the spirit of the university still upon them is due the greatest credit for a translation, to the secondary schools of the spirit and of a part of the work, of the university laboratory. Not that the secondary school shall be a miniature college or university, but the high ideals and the inspiration which emanate from these higher institutions cannot be other than forces for good in the secondary school. In biology as in other subjects, it is the teaching that is backed up by a prodigality of untold things and of unused devices which leads the student to recognize the master mind in the teacher.

In the next place the interpretation of any subject comes only as a result of following the subject's prototypes up through their evolution. One of the most valuable attainments into which we may lead our students is the ability and desire to interpret the phenomena which are about them. We cannot approach all the questions in any science, but we may give interpretative ability to the student in those phases which we do approach. With a reasonably well established terminology, much of which is common to both morphology and physiology and with the same subject matter nothing could be more natural than the consideration of function when structure is thought of, or of structure when function is known. Power of interpretation will thus bring a large measure of success in this work, not the ability to see relations within each subject merely, but the power to see relations between them as well. Neither can be taught in a satisfactory manner without the other. They are organs of a system.

In many instances the life relations are just as readily determined through the functional side as through the structural, so that the usual order of the two phases may in many cases be profitably reversed. Functional demands because of environmental and other changes have certainly been the evolutionary parent of structure and not structure the evolutionary parent of function. It could certainly not detract from, and possibly might enhance, the interest of the student were this order sometimes observed. It seems to me that the interest of the normal mind centers ultimately around the activities of things. Might morphology not have a deeper interest and consequently a deeper

meaning if it were approached from the avenue of natural interest?

This order of work leads to contact with living things and to a study of the economy of living things. A motor without an exciting current and one with such current are very different, physiologically at least. The animal is a mechanism when it is dead. Is it not true that too large a proportion of our biology deals with the mechanics of the animal or plant, as the case may be, and not with the life of the organism? However one must recognize the important truth that one of the most striking relations that the elementary student may see in an animal or plant is its adaptability, and that in comparative studies, this end is often reached through morphological work. But the study of structure comes then with a definite aim. Then, too, analogical studies are sometimes safe. But this contact with life is so important, that without it, biology loses one of its cardinal virtues. I am minded of Tennyson's words, "O life, not death, for which we pant." In this kind of study the contact with life lies the second proposed remedy.

The scope of physiology has been broadened through this recent double alliance of the two subjects, through the suggestion of the more deeply seated and more essential truths of physiology. And this lends hopefulness to the otherwise rather dismal outlook not only of general physiology, but more particularly of human physiology.

What particular phase of physiology is readily taught is worthy of consideration. In elementary work, the study of more than the general principles of nerve action, of nutrition, of motion, etc., is usually not desirable, although conditions may sometimes warrant rather detailed studies. These underlying principles of life can be given along with each type studied. When such work is completed, work along the lines of mimicry, protective coloration, parasitism, symbiosis, and degeneracy can be given with much profit. Many phases of the physiology of these things lie upon the surface of the animal, or are very evident from its surroundings. They are thus readily amenable to study. Mimicry is not a common phenomenon, but a study will develop the principles of survival and variation as readily as in any other phase of the work. Protective coloration from the physiological standpoint demands study for the reason that a majority of our common wild animals are in some measure

amenable to its workings. Parasitism, while not so common, warrants study for the reason no illustration of the relation between structure and function is more striking. Degeneracy comes in this same connection.

Insects, birds, and many of our native wild mammals lend themselves to many of the above lines of work. Find out why the woodpecker's outer toe is permanently reversed, why the tail feathers are stiff and blunt, why the tongue is barbed and is so strongly protrusible, why the head is rather heavy, why the bill is strong, and the student has then touched a number of facts bearing upon nesting habits, food, and feeding habits. These may be simple, but they are *fundamental* to an understanding of the bird. The external physiology is then very largely disposed of and internal physiology partially so. I am aware that these things seem largely ecological in character, but they are first physiological. Ecology is, in the main, simply external physiology, this latter having oftentimes an internal morphological response.

Even in the microscopic work let the physiological work be kept in the foreground. The student should be encouraged to see the animal do things as well as to see the parts of the animal. A vacuole in itself is nothing; its function is the important thing. An insistance, then, on a study of function, when morphology is being considered will result in better work and constitutes the third proposed remedy.

A NEW GAS GENERATOR.

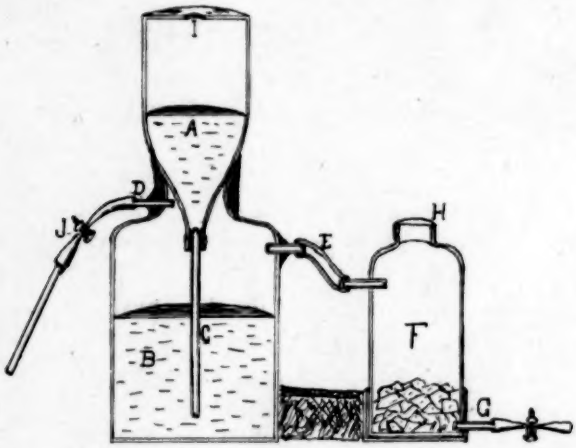
By Fredus N. Peters,

Central High School, Kansas City, Mo.

Everyone who has occasion to use a Kipp generator knows of the difficulties and annoyances which are experienced whenever it is allowed to stand for some time. The acid in contact with the iron sulphide, or whatever the material may be, becomes spent and that in the reservoir above, which is unused, must be thrown out with the other. The apparatus is seldom ready when you want it unless it has been recently charged.

Many attempts have been made to obviate these difficulties; and various modifications of the Kipp have been proposed, but most

of them are open to some objections. At the holiday meeting in December of the State Association of Science Teachers of Missouri, the model of a new form designed by Mr. Earl C. Hallar, of the department of Chemistry of Central High School, Kansas City, presented a new model of gas generator which seems to be satisfactory in every way. From the accompanying figure its construction will be readily understood. B is a bottle of about one liter capacity, having a wide mouth; A is another



bottle of about 500 cc. capacity with tapering neck which fits into B. A hole is bored through the bottom of this at I by means of a file moistened with turpentine; a tube C extends nearly to the bottom of B. F is a bottle for holding the ferrous sulphide, marble, zinc, carbide, etc., and is connected with B by means of a rather large (about 3/8 in.) rubber tubing, upon which a screw clamp, not shown in figure, is placed to regulate the flow of the liquid, which differs for different gases. F rests loosely in another larger bottle cut off short, which is fastened by wax to B quite securely. H is a ground glass stopper, which, if not gas tight, is readily made so from a few drops of wax from a candle. This is easily removed when necessary for recharging, which need not be often. For the generation of acetylene for class purposes a pint Mason glass jar is used for F. To use the apparatus the acid is poured into A at I, from which it runs down into B, and from there into F. The tube E must be large enough to permit the passage of the acid and at the same time of the gas generated in F. For generating hydrogen sulphide small quantities of acid

are all that is necessary, while for carbon dioxide more is needed. This quantity is readily controlled by the screw clamp at E. When the material in F is becoming covered with a spent acid it may readily be drawn off from G without interfering in any way with the working of the apparatus. If it is desired to prepare hydrogen instead of hydrogen sulphide, all one has to do is to disconnect at E, substitute for F a similar bottle with zinc, and proceed; likewise for carbon dioxide a bottle of marble.

Another advantage the apparatus has is that if the supply of material in F runs low while it is desired to continue the use of the gas an amount of acid sufficient to generate gas enough to nearly fill the reservoir B may be allowed to pass over into F, and while the student or instructor is drawing this off through J the clamp at E may be closed and the bottle F recharged.

Thus far the apparatus is only in the "home-made" condition, but it will probably be put upon the market for the coming season by one of the large supply houses of the country. It has been tried for some months in the laboratory and lecture room at Central High School at Kansas City, and many changes made in it since it was first tested. The result is that it seems to be now in a most satisfactory condition. Mr. Hallar has also proposed to make one other change, not shown in the figure, which, however, will render it a little more complicated. At present it is so simple that anyone can make the apparatus in a few hours, and feel sure when it is done that he will have a generator which will meet all his requirements.

Common sealing wax may be used to connect the two bottles, B and F, and to seal the tubes E and D to B, but it is not altogether satisfactory, as it gradually breaks loose. A more satisfactory cement may be prepared by melting together the following: 1¼ lb. rosin, ¼ lb. beeswax, ¼ lb red ochre or Venetian red, 1 teaspoonful plaster of Paris.

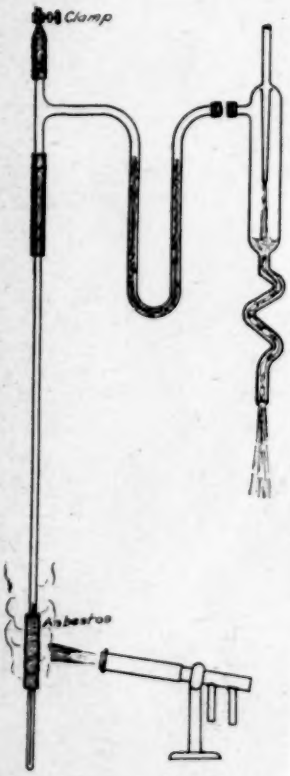
If put upon the market it is expected there will be four separate bottles for F, suited to the preparation of hydrogen sulphide, carbon dioxide, hydrogen, and acetylene, but these are merely for greater convenience and not necessary.

A METHOD FOR FILLING BAROMETER TUBES.

By Floyd R. Watson,

University of Illinois, Urbana.

Some time ago I desired to construct a simple barometer, and supposed that it would be an easy matter. A number of trials by different methods were made, however, before the tube was successfully filled. The first method tried was the one described by Ames and Bliss in the appendix to their "Manual of Experiments in Physics." In this method, the barometer tube was placed closed end down in the axis of a gas pipe two inches in diameter and closed at one end. The space between the gas pipe and the tube was filled with sand. A few centimeters of mercury were poureed into the barometer tube and the gas tube heated near the bottom so as to boil this mercury. Air and water were driven out of the mercury by this process. Then a few centimeters more mercury were poured in and boiled. This process was repeated until the tube was full. An objectionable feature found with this method was the inability to see what was going on. In one instance, it was found that the tube did not fill up after repeated additions of mercury. An inspection of the apparatus showed that the tube had cracked and broken so that the mercury escaped. An accident of this kind was dangerous because of the formation of poisonous mercury vapor.



After a number of trials, a tube was finally filled by the method hereafter described. The barometer tube, thoroughly cleaned and dried, was placed with the closed end down. The open end was connected by a rubber tube to a T-tube as shown in the figure. The top of the T-tube was closed by a rubber tube and clamped so that it

could be made air tight. Clean mercury was poured into the tube through a small funnel inserted into the rubber tube at the top. In order to boil the mercury, a gas blast lamp was used, the barometer tube being protected by a piece of asbestos paper wrapped loosely about it. Boiling was carried on at a comparatively low temperature by reducing the pressure with a water aspirator as shown. The purpose of the drying tube is to prevent moisture passing from the wet aspirator to the barometer tube. When the boiling had proceeded long enough, more mercury, already heated, was added, and the asbestos and flame were shifted up the tube so as to boil the added mercury. The process was repeated until the tube was full.

The advantages are three: 1. The entire process may be seen. 2. The mercury boils at a comparatively low temperature, and there is little danger of cracking the tube by adding more mercury. 3. None of the harmful mercury vapor escapes into the air, but is drawn to the aspirator.

When the tube was full, it was allowed to cool, then filled to overflowing. Inverting the tube in a reservoir of mercury is usually a ticklish process due to the possibility of entrapping air at the open end before the inversion and thus destroying the vacuum. This inversion was made according to a suggestion of Ames and Bliss. The index finger was encased in a piece of clean rubber tubing and placed over the open end of the tube so that a drop or two of mercury squirted out. The tube was then inverted, the open end placed under mercury and the finger removed. The mercury did not drop at once, but continued to fill the tube to the top, showing that air and water were driven out to such an exent that the adhesion of mercury to glass was strong enough to hold the mercury 80 centimeters above the level of mercury in the cistern. Repeated jarrings caused the mercury to let go and drop to the usual height. Measurement of its height with a cathetometer gave the same result to 0.1 millimeter as the standard barometer in the department.

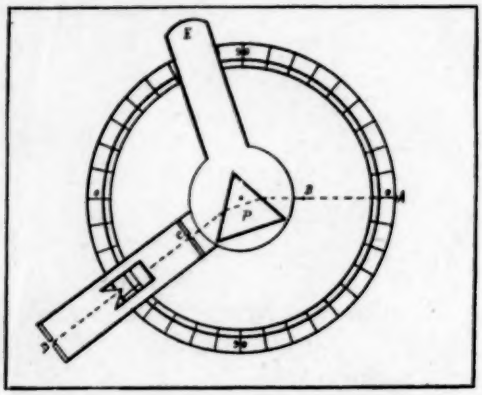
SIMPLE APPARATUS FOR INDEX OF REFRACTION.

By F. R. Gorton,

State Normal College, Ypsilanti, Michigan.

A convenient apparatus for the measurement of the index of refraction of glass is shown in the accompanying figure. The device consists of a one-half inch board about 8x10 inches upon

which is mounted a graduated scale. About the center turn of the scale two arms made of thin brass and having the same shape except at the outer ends. Arm *E*, upon which a prism is to be centrally mounted, is provided with a pivot made by soldering a small wire nail at the exact center of the circle. The pivot passes through a hole in the second arm *DC*. This arm is provided with two sights *D* and *C* and an index placed precisely in the line joining the sights. *A* and *B* are two pins placed upon the radius drawn to the zero of the scale.



In order to measure the angle of least deviation, the prism is rotated by means of the arm *E* until the well-known effect for least deviation is obtained after which the sights *D* and *C* are turned in line with the images of the two pins. The angle is then read directly from the position of the index on the scale.

In order to measure the angle of the prism, two small mirrors are attached to the refracting surfaces by means of a rubber band between the normals to which the angle is easily found. The arm *E* is first turned until *A* and *B* are in line with their images in one mirror and then the sight arm is rotated until the sights are in a normal to the other. The angle of the prism is then read directly from the index.

With little modification the apparatus can be used in determining the law of reflection of light. This is done by removing the prism and mounting a thin plane mirror precisely over the center of the scale and providing arm *E* with an index similar to that of the sight-arm. Of course the mirror must be mounted normal to a line joining this index with the center of the scale.

PHYSIOGRAPHY IN THE CHICAGO HIGH SCHOOLS.

By James H. Smith.
Austin High School, Chicago.

There are seventeen public high schools in the city of Chicago. These are widely distributed. They have a common course of study. They form a part of one system of schools, which includes also the public elementary schools on one hand, and the public normal school on the other. One board of education controls, and one superintendent presides over the entire system. Each school within the system is in charge of a principal who, within well-defined limits, has discretion regarding the work and discipline of the school. His spirit, manner and methods give tone and color to the school; but his direct authority in promoting plans and policies is far less than is usually accorded a superintendent of schools in cities of smaller size than Chicago.

The board of education prescribes all courses of study and the text-books and notebooks to be used. Of course advice and recommendations are asked from the superintendent; he, in turn confers with his principals, who, in many cases consult the teachers in their respective schools. In a few subjects the teacher is allowed to select the text-book from a list approved by the board of education.

As a result of this system the teaching of Physiography in the high schools of the city is marked by uniformity in the main; and yet it shows many variations in its minor aspects. Physiography is taught here during thirty weeks in the first year of the high school. The subject is treated as a laboratory science. The text-book in use at present is Gilbert and Brigham's "Introduction to Physical Geography."

The guide for the laboratory work is a "Laboratory Manual for Physical Geography," written by several teachers in the Chicago schools. A new manual has been recently adopted which supplants the one that has been used hitherto. Six recitation periods per week are given to the subject. Each period is fifty minutes in length, including the time required between periods, in passing from one room to another. In all classes part of the time is given to recitations and class discussions, and part of it to laboratory work. The time given to laboratory work varies from one third to one half of the total six periods per week; in a few cases it reaches two thirds. In this respect the teacher is given a good

deal of latitude to follow the plan that he likes best. Six periods per week are given in order that one or two sessions per week may extend through a double period for laboratory work. The number of double periods per week is not the same in all of the schools of the city, and often it is not the same for all of the classes of a single school. The differences are due in part to the ease or difficulty with which the program of the school can be arranged; but some of them are for pedagogical reasons. Some classes have two double periods and two single periods per week; some have one double and four single periods per week; while still others sacrifice the sixth period and have five single periods per week. The preference of the writer is one double and one single period per week, upon days not consecutive, for laboratory work, and three single periods for discussion and recitation.

These differences in treatment and emphasis, together with the fact that more work is given in the text-book and laboratory manual than can be done within the allotted thirty weeks, made it desirable to select from the total content, certain parts which should be given in each class. This is the more necessary on account of frequent removals from one part of the city to another, and the consequent transfer of pupils from one high school to another within the system. In addition to this, admission to the Chicago Normal School is gained through examinations based upon the high school curriculum. Pupils have sometimes suffered because questions set by the examiner were taken from the part of the subject omitted by the high school instructor. Accordingly, with the approval of the superintendent of schools, and in collaboration with the head of the department of geography in the normal school, the high school teachers of pysiography agreed upon certain portions of the text-book and certain correlated laboratory exercises which should be studied by every class. These constitute the minimum requirements for the completion of the subject. It is expected that every class will go beyond these requirements; indeed, most of the classes go far beyond them. But what in addition, shall be taken, and what omitted is left to the discretion of the teacher. This arrangement was adopted on April 26, 1906, and has been in operation since that date. It seems to be giving satisfaction to all concerned. The minimum requirements of text-book and of laboratory work are given below, correlated with reference to each other. The chapters given refer to the chapters of Gilbert and Brigham's "Introduction to Physical Geography."

Topics	Laboratory and Field Exercises
CHAPTERS I & II.	
THE EARTH:	Exercises with globes, using meridians and parallels.
Form.	
Size.	Longitude and Time relations.
Distance from Sun and Moon.	Lengths of Day and Night.
Movements.	Map of Western Hemisphere (globular projection), with outline of continents.
Seasons.	
CHAPTER III.	
RIVERS:	Topographic Maps of narrow and of open valleys and of flood-plains.
How a river works:	
(a) Destructive.	
(b) Constructive.	
Conditions governing rate of cutting and of building.	
Forms of Valleys.	
CHAPTERS IV & V.	
MINERALS, ROCKS AND	Study of quartz, feldspar, hornblende, calcite, mica.
WEATHERING AND EROSION:	
The Chief Agents and how they work:	Study of sandstone, limestone, shale, granite, slate, marble, coal.
Water.	
Change of Temperature.	
Frost.	
Wind.	
Results produced.	
Soils.	
CHAPTER VI.	
GLACIERS:	Topographic maps of glaciated regions.
Description.	
How Produced.	Study of glacial pebbles and of till.
Present Distribution.	
The Ice Age in North America.	
CHAPTER VII.	
PLAINS:	Topographic map of a plain not much modified.
How Produced.	
Economic relations.	Topographic map of a dissected plain.
CHAPTER VIII.	
MOUNTAINS AND PLATEAUS:	Topographic map of a dissected plateau.
Plateaus:	
How Produced.	Topographic map of a low mountain ridge.
Economic relations.	
Mountains:	Topographic map of a high mountain ridge.
How produced.	
Influence upon climate.	

CHAPTER IX. VOLCANOES: Phenomena of eruption. Causes of eruption. Products of eruption. History of a cone.	Topographic map of a volcanic mountain.
PARTS OF CHAPTERS III, VII & VIII. GEOGRAPHIC REGIONS: Description of the chief geographic regions of the United States, with emphasis upon local geography.	Exercises based upon the Chicago Folio, U. S. Geological Survey or upon Salisbury and Alden's "The Geography of Chicago and its Environs."
CHAPTER X. THE ATMOSPHERE: Composition. Pressure. Height. Humidity. Dew. Frost. Fog. Clouds: How produced. Chief kinds. Rain: How produced. Distribution. Temperature (Thermometers). How the earth is warmed and cooled. Compare warming and cooling of land with that of water. How the air is warmed and cooled. Adiabatic changes.	Make a temperature curve for Chicago. Make a graph showing precipitation at Chicago. Make an isothermal map of the United States. Compare summer isothermal charts with those of winter.
CHAPTER XI. WINDS, STORMS, CLIMATE: The Barometer. Prevailing Westerly Winds. Temperate Latitude Cyclones. Ferrell's Law. Trade Winds. Monsoons. Land and Sea Breezes. Thunderstorms. Tornadoes. Hurricanes. Planetary Wind Zones. Climatic Regions.	Make an isobaric map of the United States. Study Temperate Latitude Cyclones and Anticyclones, using U. S. Weather Maps. Forecasting of the weather.

CHAPTER XIII.

THE OCEAN:	[No laboratory exercises upon the ocean were in the manual from which this outline was prepared. At present the teachers are using exercises from the new manual referred to above].
Waves:	
Cause.	
Height.	
Tides:	
Phenomena (omitting causes).	
Currents:	
Circulation.	
Influence upon climate.	

CHAPTER XIV.

MEETING OF LAND AND SEA:	Topographic map of a low, sandy coast; or a field trip to a beach.
Wave Work.	Topographic map of a high, rocky coast.
Cliffs.	
Beaches.	
Rising and Sinking Coasts.	
Harbors.	

The teachers expressed the opinion that Chapter XV on "Life" and Chapter XVI on "The Earth and Man" should not be taught as such, but that the subject matter therein contained should be distributed among the various topics to which it applies, thus emphasizing the relation of the subject to the life of man.

PERSONAL.

President James of the University of Illinois announces that Dr. W. C. Bagley, teacher in the State Normal School in Oswego, New York, has been appointed Professor of Education in the University of Illinois.

Dr. Bagley took his bachelor's degree at the Michigan State Agricultural College in 1895, his master's degree at the University of Wisconsin in 1898, and his doctor's degree at Cornell University in 1900.

Following graduation at Cornell in 1900, Dr. Bagley remained at that institution one year as assistant in Psychology. He was principal of public schools in St. Louis, 1901-1902; professor of Psychology and Education, and director of training in the Montana State Normal School, 1902-1906; vice-president of that institution, 1904-1906; superintendent, training department, Oswego, N. Y., State Normal School, 1906-1908; on summer session staff Teachers' College, Columbia University, New York, 1998; institute instructor in Montana, South Dakota, Indiana, New York, Pennsylvania and Ohio.

Dr. Bagley is the author of "The Apperception of the Spoken Sentence," "The Educative Process," "Class Room Management," and other articles along educational lines. He is the founder and co-editor of the Inter Mountain Educator, advisory editor School Review, and associate editor of the Journal of Pedagogy.

Dr. Bagley will begin his work at the University of Illinois, September 1, 1908.

SOME QUESTIONABLE TERMS AND DEFINITIONS USED IN ELEMENTARY MATHEMATICS.[1]

By G. A. Miller,

University of Illinois, Urbana, Ill.

Three important mathematical ideals are, to use no terms or definitions which are liable to be misunderstood, to use the most direct and concise expressions, and to use a world language. The developments toward these ideals have been slow and a great deal remains to be done. The present paper is devoted to the consideration of several terms and definitions which are widely used but do not appear to be free from objections. Many of these considerations involve questions of judgment rather than of demonstration—relating to the better or worse rather than to the right or wrong. We begin with the so-called indeterminate forms:

$$\frac{0}{0},\ \frac{\infty}{\infty},\ \infty\cdot 0,\ \infty-\infty,\ 0^0,\ \infty^0,\ 1^\infty$$

Many of the leading mathematicians of all countries[2] which contribute to mathematical advancement agree that division by o has no place in elementary mathematics, and that these forms are really meaningless. Yet some of them persist in speaking of *evaluating* expressions when they assume such a form and in calling the form indeterminate instead of meaningless. Comparativeley little harm is generally done since authors are apt to state in the development of the subject that they are seeking the limit of the value which such an expression approaches when the variable approaches a value which makes the expression meaningless. In this connection the term evaluate is therefore used only as an abbreviation for a more accurate form of statement, but it has led to so many misconceptions that the wisdom of its use seems questionable. Where conciseness and accuracy conflict the latter should take precedence.

As each of the given forms may be reduced to the first one, all of them involve dividing by o and hence are meaningless. In view of the fundamental importance of this subject it seems desirable to call attention to a very questionable stock illustrative

[1] Read before Section A of the American Association for the Advancement of Science, January 1, 1908.

[2] Cf., School Science and Mathematics, November, 1907, p. 667.

example. Many authors proceed as follows with a view to finding the value of

$$\frac{x^2-a^2}{x-a}$$

when $x=a$. Letting y equal this fraction and then clearing of fractions they arrive at the equation $y(x-a)=x^2-a^2$ or $(x-a)\ (y-x-a)=0$. As this equation represents two straight lines, one being parallel to the y axis, they assume that

$$y=\frac{x^2-a^2}{x-a}$$

has the same locus and with this assumption the illustration works beautifully. The only trouble with this is that the assumption is false, since the locus of the latter equation is only a part of the locus of the former. That is, the locus of the latter consists of every point on the line $y-x-a=0$ with the exception of the point $(a,\ 2a)$. This stock illustration appears to be an effort to hide an algebraic difficulty in the language of analytic geometry and is not the only instance where many students are deceived by putting a difficulty into a somewhat unfamiliar dress.

While an expression like $\frac{x^2-a^2}{x-a}$ is meaningless when $x=a$ there is no logical difficulty in asigning an arbitrary value to it for this particular value of x. In particular we may assume that this arbitrary value is $2a$ since it is the limit of the values which the expression assumes when x approaches a but is not equal to a. But it should be observed that there is a vast difference between asigning a value to an expression for a particular value of a variable, and evaluating it for this value in case it can be evaluated. The former process can scarcely be said to belong to elementary mathematics and is therefore generally a questionable practice in elementary mathematics. At any rate it should be employed only after its logical significance has been clearly pointed out.

Among the elementary text-books the trigonometries are the most flagrantly inaccurate. Some of these, like Wheeler and Wells, openly and shamelessly divide by 0[3] while others commit the same sin more covertly by saying $\tan x=\frac{\sin x}{\cos x}$ without any restrictions on the values of x, and by affirming that $\tan 90^\circ=\infty$.

[3]In regard to Burkhardt's questionable definition of a/o the reader should consult Bôcher, Bulletin of the American Mathematical Society, vol. 5, (1899), p. 182, and Osgood, Lehrbuch der Funktionentheorie, 1907, p. 6.

The ordinary definition of the tangent of an angle does not apply to the special cases when the angle is an odd multiple of 90° and hence in these cases the tangent is not included in the general definition. Moreover, the student is told that the tangent of a given angle is a fixed number, which can therefore not have the properties of ∞. It would appear much wiser to state explicitly that such a function as $\tan x$ is not defined when x is an odd multiple of 90°, and has therefore no meaning, than to imply that division by 0 is a legitimate operation under the ordinary rules of elementary algebra.

The following definition of multiplication with slight modifications is found in a large number of text-books: "Multiplication is doing to the multiplicand what has been done to unity to produce the multiplier." The fact that it has been so extensively adopted seems to imply that it conveys a correct notion to most of the students' minds. Yet it is very vague and readily admits a vast number of false interpretations as has been observed by others. For instance, four may be obtained by doubling unity and squaring the result, but multiplying by four is not generally equivalent to doubling the multiplicand and squaring the result. An almost endless number of other false results could be reached by following the letter of this definition of multiplication. While the explanations and illustrative examples may leave no doubt in the student's mind in regard to the proper interpretation of such a definition yet it seems questionable whether such extremely vague definitions should have a place in a modern text-book, especially since correct definitions are easily accessible in such works as the *Encyclopädie der Elementar Mathematik* by Weber and Wellstein.

The fact that the last letters of the alphabet are generally employed to represent unknown constants as well as to represent variables has led to considerable confusion. In support of this I need only quote the following definition from a recent algebra: "The letters of an equality which are restricted in value are called variables." In this work there appears to be no distinction in name between an unknown which can have only one value in a given problem and a variable which is supposed to be running through a never ending sequence of numbers. The difference between the variables which are considered in the construction of the graph of an equation and the unknowns which are in-

volved in a system of n simultaneous equations involving n unknowns is so marked that it appears unfortunate that it is not at first brought out by the use of different symbols, as is generally done in the case of constants and variables. At any rate, this difference in the possible meanings of the same symbol should be emphasized.

In the case of a system of n linear equations (at least one being non-homogeneous) involving n unknowns, I see no good reason for not employing the subscript notation in conformity with the common practice in analytic geometry where the coördinates of a fixed point are commonly represented by adding a subscript to the symbols for the variables. In considering the graph of the separate equations, $n < 4$, the subscripts should be omitted since the unknowns are to be replaced by variables. In the case of equations of higher degrees new difficulties present themselves as the unknowns may then have more than one value. As the most useful and the most elementary concept of a variable is that of a symbol which may be replaced successively by the different numbers of a never ending sequence, the term variable should be restricted to this meaning in elementary mathematics, even if it is sometimes desirable in higher mathematics to use this term for a symbol which is supposed to be replaced successively by only a finite number of different numbers. This is so much the more true because the latter concept of variable is generally quite different from that involved in finding the roots of an equation in elementary algebra.

In such matters it is very difficult to arrive at tenable conclusions since the teacher and the author must be allowed some freedom, otherwise the door toward better things would be closed. On the other hand, it is extremely important that people who have been trained in different schools should be able to understand each other and hence it is desirable that such a cosmopolitan subject as mathematics should have a world language wherever this is possible. In this connection it is to be regretted that some of our most popular text-books define an equation of the form $ax^2+bxy+cy^2=d$ as a homogeneous quadratic equation, while such an equation is not commonly called homogeneous since it involves both known and unknown terms, or both variable and constant terms if x and y are regarded as variables. It is homogeneous in the unknown terms as is stated by most authors.

One of the most difficult questions that presents itself in teaching an elementary subject is to decide upon the limits to which one should carry a discussion. In division, for instance, we have already insisted on the exclusion from elementary mathematics the consideration of the quotient when the divisor becomes 0, while in higher analysis it may possibly be desirable to assign a meaning to the symbol $a/0$. In fact, the question of assigning a more or less arbitrary value to a symbol belongs, in general, to higher mathematics but even here it appears necessary to admit exceptions; e. g., $\underline{|0}=1$. While the older school algebras practically confined themselves to the consideration of unknowns the more recent text-books wisely develop the concept of variables, especially by the consideration of graphs. This extension gives rise to a number of new difficulties in regard to the limit to which a discussion should be carried. For instance, no one can fully consider the simple equation $12x=5y$ without observing that for every real value of x between 0 and 5 there is one and only one real value of y between 0 and 12, and vice versa. Hence there are just as many real numbers between 0 and 5 as there are between 0 and 12. This almost compels us to tell the student that an infinite multitude has the property that a part is equivalent to the whole even if this property does not belong to any finite multitude no matter how large it becomes. Infinity has some properties which are not limits toward which properties of finite numbers tend when they become very large.

Our elementary algebra thus brings us face to face with the so-called actual infinity just as arithmetic brings us very early to potential infinity in the never ending series of natural numbers. While these concepts and perhaps also that of fictitious infinity must be dealt with candidly and fairly, yet it is questionable whether they should be emphasized in our elementary teaching or should enter in any examination questions. Although the infinite is all around us the finite demands the first attention of the students of elementary mathematics.

The fact that many mathematical terms have more than one meaning is a source of a great deal of confusion. In some cases (e. g., the different meanings of circle) this could readily be remedied by an agreement among educators, and it is to be hoped that these sources of confusion will rapidly disappear. As educators we have no right to be indifferent to any source of trouble to the students. In other cases, the roots of the difficulty

lie much deeper. For instance, the term division is used in two distinct senses in arithmetic. According to one meaning of these term it is required to find an integral quotient and a remainder which is less than the divisor, while according to the other it is required to find a number which multiplied into the divisor produces the dividend. Only the latter of these is the inverse of multiplication and hence we should not make the statement that division is the inverse of multiplication without specifying what is meant by the term division. These two closely related processes are both necessary but it is doubtful whether the matter would be simplified by the use of distinct terms. The fact that ratio and division are commonly represented by the same symbol has led to so much confusion as to make it a questionable procedure, especially since the remedy is close at hand.[4]

From elementary analytic geometry it follows that $xy=0$ represents the coördinate axes and that $\frac{1}{xy}-1=0$ represents the hyperbola whose equation is commonly written in the form $xy=1$. The product of the first members of the first two equations evidently represents the same hyperbola. From this example it results that such rules as $uv=0$ has for its locus the combined loci of $u=0$ and $v=0$ should be stated with the necessary limitations. This is, however, not done in many of the popular text-books on analytic geometry. While the above criticisms apply to many text-books it seems desirable to add that most of them relate to matters of minor importance and that a text-book may be very valuable even if it is subject to some of these criticisms. Such flaws should be considered in choosing a text-book but they should not hide especially meritorious points of much greater importance to the student.

Most of the antimony produced in the United States is contained in antimonial lead.

It is claimed by some men that zinc amalgam is beneficial in promoting amalgamation, due to voltaic action between the zinc and the copper plates.

It is asserted that the deposition or precipitation of the gold in the pebble beds of the Rand banket might be accounted for by the action of terrestrial electric currents.

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[4]Cf. Encyclopèdie des Sciences Mathematiques, vol. 1, p. 44.

THE MISSOURI SOCIETY OF TEACHERS OF MATHEMATICS AND SCIENCE.

Division I: Mathematics.

RECOMMENDATIONS FOR A HIGH SCHOOL COURSE IN ALGEBRA.

(Report of a committee appointed May 4, 1907.)

To the Missouri Society of Teachers of Mathematics and Science:

Your committee, appointed at the Spring meeting of the Society May 4, 1907, to consider the teaching of algebra in secondary schools and to report upon it, begs to submit the following for your consideration:

A QUOTATION.

This report will be based in part upon the report of the committee of the American Mathematical Society, published in the Bulletin of the Society, November, 1903, page 74. Quoting from that document: "At the summer meeting of the American Mathematical Society, September, 1902, a special committee was appointed to prepare standard formulations of college entrance requirements in mathematics, in coöperation with committees already appointed by the Society for the Promotion of Engineering Education and the National Educational Association. * * * Advice of value has been sought and obtained from other members of the Mathematical Society and from secondary teachers. * * * The order in which the subjects in the topics considered is presented below does not imply preference of the committee either as to the order of teaching or topics. * * * It is the opinion of the committee that these are subjects and topics which according to the best present usage, should be offered for admission to colleges and scientific schools. * * * The formulation is not to be interpreted as exhaustive. * * * It is expected that further details will be determined in accordance with the needs of the particular college, school or teacher. * * * The committee is of the opinion that no formulation should be considered as having more than temporary validity. * * * No advantages attendant npon uniformity of definition will counterbalance any tendency of the definitions to retard progress in secondary education in mathematics. It is recommended that if the definitions are approved they be revised at intervals, perhaps, of ten years."

Passing now to that portion which concerns algebra the committee just quoted recommends: "Elementary Algebra: 1. The four fundamental operations in rational algebraic expressions. 2. Factoring, determination of the highest common factor and lowest common multiple by factoring. 3. Fractions; including complex fractions, ratio and proportion. 4. Linear equations, both numerical and literal, containing one or more unknown quantities. 5. Problems depending upon linear equations. 6. Radicals, including the extraction of square root of polynomials and of numbers. 7. Exponents, including fractional and negative. 8. Quadratic equations, both numerical and literal. 9. Simple cases of equations with one or more unknown quantities that can be solved by the methods of linear or quadratic equations. 10. Problems depending upon quadratic equations. 11. The binomial theorem for positive integral exponents. 12. The formulas for the nth term and the sum of the terms of arithmetical and geometrical progressions, with applications. 13. It is assumed that pupils will be required throughout the course to solve numerous problems which will involve putting questions into equations. Some of these problems should be chosen from mensuration, from physics, and from commercial life. 14. The use of graphic methods and illustrations, particularly with the solution of equations, is also expected." This report is signed by Professor H. W. Tyler of the Massachusetts Institute of Technology; Professor T. S. Fiske, of Columbia University; Professor W. F. Osgood, of Harvard University; Professor Alex. Ziwet, of Michigan; and Professor J. W. A. Young of Chicago.

Preliminary Statement.

We would explicitly state that the high school course should be planned mainly for the students who never go to a university or a college. It seems to us that this should be done, for we are convinced that we shall make great error if we do not provide especially for those for whom this training is the last. For the student going to college a special, almost private, course may well be recommended.

In all of our actions, however, it seems evident that we should bear in mind the fact that we are not dealing with any specialized group of students but that we are considering the teaching of the subject as handled in the average high school. There can

be made no division of students into the logical classification of prospective college students, technical students, and the like, as the conditions generally require that they must be handled *en masse*. Consequently, we must continually avoid any treatment which will be too abtruse for the average, we must temper the phraseology to the understanding of these children, and at the same time we must not omit any topics which will be vitally essential to a proper and scientific understanding of the subject by those who will eventually need it for a mastery of engineering and higher mathematical problems.

Returning to the detailed discussion of the course we would recommend:

I. Regarding the Four Fundamental Operations.

(a). The four fundamental operations should be carried out principally for rational algebraic expressions only; and only the very simplest examples in radicals and in fractional exponents should be given in the course (see also Art. VII.).

(b). The teachers should recognize that the process for long division is not so directly useful as is generally supposed, since it is only successful for those expressions which are the result of multiplication. The great difference between the importance of long division in arithmetic and that of long division in algebra should be recognized. However, the technique which this work develops is valuable in the other fundamental operations, and for this reason the process should be given as heretofore.

(c). Examples should be given in the four fundamental operations and in factoring, in which the terms must be rearranged by the student before the problem is solved.

(d). Some of the most elementary applications of the fundamental operations may be used before the chapters in which these operations are expressly treated; thus $6m+3m=9m$; $2x+6=2(x+3)$ and similar excessively simple forms may be introduced with safety in the introductory portion of the book.

II. Regarding the Definitions.

(a). Definitions should be given in close connection with the work to which they apply.

(b). The definitions in our elementary books should conform to standard notation where possible, and in no case absolutely

conflict with standard notation. As an example of this principle, attention is called to the misuse of the word "polynomial" in many texts; the established meaning is a rational integral expression. The sum of any terms whatever—which is not necessarily a polynomial—may be called simply an expression.

(c). Definitions may be omitted altogether and replaced by concrete illustration and example when the real definition is difficult. Thus straight line, plane, and other concepts in geometry; multiplication, irrational numbers, limits, infinite series, etc., in algebra, may best be left undefined. Attention is called to a faulty definition of multiplication in many recent texts—involving an ambiguity in "obtaining the multiplier from unity."

III. Regarding Factoring.

(a). The Euclidean process for highest common divisor should be omitted entirely from the course.

(b). The work in factoring should be regarded as simply the reverse of certain typical multiplications, aside from the mere question of rearrangement of terms.

(c). Theorems analogous to the remainder theorem or others of equal difficulty should be postponed to a later course.

IV. Regarding Fractions.

(a). Ratio and proportion should be treated directly on the basis of equality of fractions.

(b). Inasmuch as we have agreed tc exclude the Euclidean process for highest common divisor, a new concept should, and in fact, must be introduced in the treatment of addition of fractions and reduction of fractions to lowest common terms—what may be called the "practical common multiple" or the "lowest practical multiple" of two expressions, by which is meant the least multiple which can be found by the methods which are available to the student. It should be remembered that it is impossible for the student to find the lowest common multiple, strictly speaking, without the use of the Euclidean process, except in special examples. We would recommend, however, that the new concept should be interpreted strictly to mean the least multiple at the command of the student so that he be not allowed to satisfy himself with slipshod work.

(c). Examples in complex fractions should be restricted to

the simplest types—those which are equivalent to the quotient of two simple fractions.

(d). Inasmuch as proportion is really expressed by the equation $y=kx$, where k is a constant and y and x express the varying values of two varying quantities, it is recommended that we should introduce, in addition to the usual definitions of proportion between four fixed quantities the notion of proportionality of *varying* quantities at this point, as follows: "The values of two varying quantities are in proportion if their ratio is a constant," e. g., if butter is 30 cents per pound $p=30n$, where p is the price in cents and n is the number of pounds. It is evident that any two values of p and the corresponding values of n are in proportion, since the ratio p/n always$=30$.

(e). It is also recommended that the student be shown at this point that the equation $y=kx$ is a straight line in graphical representation (see also Art. V). Finally the subject of variation, which is also given by the equation $y=kx$, should be given at this point, or should be directly connected with this work when it is given.

V. Regarding Linear Equations.

(a). Linear equations of a simple type should be treated in an introductory chapter. The committee believes that the study of equations is of fundamental importance in algebra.

(b). Examples should be given in which linear equations are to be solved for other letters than x; however, in doing this, care should be taken that the student understands when he has solved an equation, in order that he should not later make serious errors in simultaneous equations, in imagining that he has solved for a letter when that same letter occurs in his answer.

(c). In the treatment of simultaneous linear equations the algebraic work should be accompanied or preceded by the graphical interpretation of such equations and their solutions, in order that this graphical work be of assistance to the student in the algebraic solutions.

(d). The examples should be restricted principally to two equations which contain two unknowns, with at most a few examples of three equations which contain three unknowns.

(e). The three possibilities—a single solution, no solution, and an infinite number of solutions of two equations in two un-

knowns—should be brought out by means of graphic figures; and examples should be given in which each of these cases occur.

VI. Regarding Problems.

(a). The problems should be restricted as far as possible to those which are conceivable to the human mind, though they need not be directly practical in the narrowest sense. They should at least be based upon data which might conceivably be known to some human being, the answer required being one which he conceivably might not know and might desire to find. It is our opinion that problems in which the answer surely would be known before the data are destructive of the students' interest and attention. There is, however, no objection to the statement of problems in pure numbers; for example, "If the sum of two numbers is 15 and their difference is 5, find the two numbers." The objection is to clothing such problems in supposedly practical language which is easily seen to be hypocritical.

(b). In the introduction of problems on mensuration the formulae in areas, etc., should be given without an attempt at proof, but great care should be taken that the student understands the meaning of these formulae and that he be convinced of the reasonableness of them and of the concepts which are used in the statement of the formulae. [See also (c).]

(c). In problems dealing with physics and other applications of mathematics the remarks made regarding mensuration are to be observed. Moreover, no formulae should be taken from physics or other applications which involve concepts whose explanation would consume a considerable time. Thus, problems involving *specific heat* should be omitted; but those in *falling bodies,* for example, may be used, if the concepts involved are clearly explained.

(d). In problems from commercial life care should be taken that the operations involved are operations actually used in business; and the remarks made above under (b) and (c) should be carefully observed.

VII. Regarding Radicals.

(a). The subject of radicals and the subject of exponents should be combined from the first, since the two notations $\sqrt[n]{x}$ and $x^{1/n}$ are merely two identical notations, either of which may be introduced as the original notation for the nth root. If this

be done the duplication of work in radicals and fractional exponents may be avoided.

(b). The more difficult operations in radicals should be postponed until late in the course (for example, until after the treatment of simultaneous quadratics), only those simple operations in radicals which are absolutely necessary for the solution of quadratic equations being given before quadratics.

(c). The process for cube root should be entirely omitted.

(d). The process for square root should be retained but it should be emphasized less than has been the custom. On the other hand, the graphical processes for square, cube and other roots by means of equations $y=x^2$, $y=x^3$, etc., should be given, both on account of their practical value and on account of the insight which they give into the definition of these roots as irrational quantities.

(e). In the more detailed work on radicals, even though it come late in course, as recommended above, the more complicated process should be entirely eliminated. The limit of complication should be the rationalization of binomial denominators, and the fundamental processes should be restricted to operations upon surd binomials, except for a very few illustrative examples.

(f). In the solution of radical equations it is recommended that only the very simplest examples be given; that an explanation be given for the occurrence of the apparent solutions which do not satisfy the original equation; and that we insist rigidly upon verification in every example as the only means of deciding which results are valid. These remarks apply of course to problems in which a radical is indicated by a fractional exponent as well as to those in which the traditional sign is used.

VIII. Regarding Quadratic Equations.

(a). Easy quadratic equations which can be solved by factoring should be given early, at least in the chapter on factoring; the general solution of quadratics by factoring should not be given in that chapter.

(b). The method by completing the square should be made the fundamental method for the solution of quadratic equations in the chapter devoted to that subject.

(c). The formula, as such, should not be introduced until after the method by completing the square is thoroughly mas-

tered; in any event the formula should not be regarded as of equal importance as a method of solution.

(d). The method of solution by factoring as a general method should be given at most briefly and should not be regarded as one of the principal methods of solution of quadratic equations. [See, however, (a) above.]

(e). The very simple and useful problem of forming a quadratic equation whose roots are given in advance, and the allied problem of the relations between the roots and the coefficients should be given a prominent place in the work and illustrated by a variety of examples.

IX. Regarding Equations Involving Quadratics.

(a). The graphical representation of simultaneous equations involving quadratics and their solution should accompany or precede the algebraic method of solution, as in Art. V.

(b). The pairs of values of two unknowns should be carefully explained, and the student should not be allowed to give the values of the unknowns without correctly pairing them.

(c). The work of solving simultaneous equations should be restricted to simple types, especial stress being laid on those examples in which one equation is linear.

(d). The graphical work should be restricted both in amount and in extent so that very few, if any, curves are introduced beyond the straight line, the circle, and the parabola.

(e). The graphical solution of a single quadratic equation should be given either here or in the chapter on quadratics, preferably the latter.

(f). A very few more difficult examples should be given which cannot be solved by the processes of elementary algebra, but which can be solved approximately by the graphical method (e. g., $x^2+y=7$; $x+y^2=11$).

X. Regarding the Binomial Theorem.

(a). No other case than that of a positive integral exponent should be treated.

(b). The general theorem for any positive integral exponent should be postponed until very late in the course, or kept for a review course, only the cases $n=1$, $n=2$.....$n=5$ being given in the regular course.

(c). Any infinite series arising from the binomial theorem—i. e., and consideration of the case of fractional or negative exponents—should be absolutely excluded.

XI. Regarding Progressions.

(a). The work should be restricted to finite progressions, and no infinite progression or series should be treated at any time.

(b). As recommended in the report quoted above only the formulae for the nth term and for the sum of the terms should be emphasized.

(c). The subject of harmonic progressions should be omitted.

XII. Regarding Graphical Processes.

In addition to the recommendations made above in the consideration of other topics, we would add the following recommendations:

(a). The drawing of very simple graphical pictures, such as those which represent the temperature at different times, the price of a commodity (e. g., wheat) at different times or in different amounts, immigration and similar statistics, should be given early in the course, on account of their attractiveness and their value. In particular the price curves, which are straight lines (see Art. IV.), should come very early. However, this work should be restricted in amount and should be adapted to the needs of the pupils.

(b). Graphical work should be introduced whenever it is of direct assistance to the student, either in helping him see the algebraic work or in holding his interest; but it should not be introduced for its own sake in topics in which its usefulness is not clear.

(c). In the treatment of indeterminate equations, if this topic is taken up at all, the graphical form should be especially insisted upon, since here the graphical interpretation of an equation finds its most characteristic application.

(d). Every caution should be taken that graphical work be not overdone; in particular the nomenclature of analytic geometry should be absolutely excluded.

XIII. Regarding Logarithms.

The usual work in logarithms is recommended. This treatment

should be brief and should be directed chiefly toward the practical use of logarithms.

XIV. Regarding Omissions.

The principal topics omitted from the traditional course are as follows: Highest common divisor by the Euclidean method; cube root; infinite series; permutations and combinations; choice and chance; inequalities; continued fractions and the like; an express treatment of imaginary quantities as such. Regarding imaginary quantities we feel that any treatment should be postponed until after the main body of the course has been completed and given only to those students who desire it for entrance to special colleges. There seems to be great reason why the work should be restricted to real numbers except for occasional hasty mention, though we should not hesitate to write the formula for the solution of a quadratic equation in radicals, explaining to the student that the result is meaningless for the present in case the quantity under the radical sign is negative, and stating the usual test for imaginary quantities as a test which determines when the equation has solutions which have a meaning and when it has solutions which are (at present) meaningless.

XV. Regarding Correlation.

(a). Reasonable effort toward correlation of algebra with other mathematical topics and with other sciences should be attempted in a conservative manner.

(b). Applications to geometry should consist principally of the graphical processes mentioned above and of examples involving mensuration formulæ and other formulæ taken from geometry.

(c). No attempt should be made in the course in algebra to give logical demonstration of any formulæ taken from any other mathematical subject, or from another science, but these formulæ should be given to the student without proof, with a full explanation of all of the concepts which are involved.

Conclusion.

In presenting this report to the teachers in this state none of the recommendations made should be taken as absolutely binding or final. It is unquestionably true that the different demands of

the different schools will cause frequent variation from the program outlined above, or from any program which may be outlined by any committee. Moreover, the individual initiative of the teacher in deciding for himself which topics are to be given and which methods are to be used in teaching is of incalculable value in inspiring the work of that teacher and in making it effective in his class.

Again the standards which we now maintain in the teaching of algebra in secondary schools are subject to radical changes as the schools develop in the future and as our ideas advance. Suggested changes should not be regarded as revolutionary nor as radical, for improvements in method are to be expected continually in any subject which is not dead.

It is hoped, however, that the general spirit of this report will meet the approval of the rank and file of teachers in the state, and that it will be of assistance in formulating plans for better instruction in algebra in our secondary schools.

Submitted to the Missouri Society of Teachers of Mathematics and Science Division I, Mathematics; and to the State Teachers' Association, Mathematics Section, Joplin, Mo., Dec. 26, 1907.

(Signed)

E. R. HEDRICK (Chairman),
University of Missouri, Columbia.

C. A. AMMERMAN,
McKinley High School, St. Louis.

E. M. BAINTER,
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H. C. HARVEY
State Normal School, Kirksville.

R. H. JORDAN,
St. Joseph High School, St. Joseph.

Adopted Dec. 27, 1907.

SOME BY-PRODUCTS OF BIOLOGY TEACHING.

By Benj. C. Gruenberg,
DeWitt Clinton High School, New York City.

In the manufacture of illuminating gas by distillation from coal, there is left a sticky, tar-like mass that was for years a source of annoyance to the manufacturers of gas, and to the neighbors of the manufacturers. It was a waste product that was not only of no value, but a perfect nuisance, since it had to be removed from the gas stills and disposed of in some way. It was thrown into the streams, which killed the fish and aroused the angry protests of the farmers; it cost so much to handle the stuff that it was a heavy charge on the manufacture of gas, but it was impossible to make gas without producing considerable quantities of it. This nuisance remained unabated until an experimenting chemist hit upon a method of using the nasty stuff for making certain brilliant coloring matters, which are now used by the ton for dyeing ladies' dresses and chromosomes. I don't know whether the price of gas to the consumer has gone down on that account, but it would seem that if for some reason it should no longer be worth while to manufacture gas for lighting and heating purposes, it might still be worth while to make the gas and blow it off into the air, just for getting the coke, the ammonia and the coal-tar, the by-products of this process. I am not prepared to quote the exact figures, but at the present time the substances prepared from coal-tar exceed in actual value that of the gas for which the coal was primarily distilled, by some hundreds of percent.

Many modern industries are founded upon the by-products of other industries. We are so economical that not a scrap of material is wasted in the working up of cattle to make canned beef, glue, soap, glycerine, oleomargarine, sausage casing, fertilizer, shawl-straps, and I don't know what else; the total value of these by-products of the canning industry may or may not exceed the value of the net meat, but they are certainly worth saving. If they were not saved and utilized, it would mean smaller profits for those engaged in the business, or dearer meat for the rest of us, or both. If we should all stop eating meat, it might conceivably be still worth while to slaughter cattle for the other

Read before Section B, New York State Science Teachers Association, at Twelfth Annual Meeting, Cornell University, December, 1907.

products, the by-products. My point here is simply that in the industries the by-products, or the potential by-products, may not be profitably neglected.

In the business of teaching, much doubt has been cast upon the actual value of the product, from time to time. There are men and women by no means stupid who question not only the value of college and high-school education, but even that of the bulk of our elementary school education. There is great uncertainty in the minds of the public, and in the minds of many teachers, too, as to the real worth to the children of the results of the various efforts comprised under the name of teaching. We hear a great deal about the three R's, and fads and frills, about preparation for life and culture and training for efficiency. And the only reason that any one of us who takes the trouble to speak up may get a hearing is, that we are all at sea, teachers as well as the taught, and the parents of the taught. It may well be that the process has not been conducted economically, all things considered, that some of the possibilities have been neglected. We must look to the by-products.

When I speak of the by-products of teaching I do not mean the small graft in the way of sample copies of new books, or free tickets to an occasional lecture; nor do I mean the money you can make on the side because you have more leisure than the bricklayer; nor do I mean the glow of satisfaction that you feel when the minister speaks of consecrated lives, or the gratification yielded by an appreciative word from a former pupil. I have in mind solely the value of the product and of the by-product to the pupil, that is, to the taxpayer, the citizen, the laity. While personally I believe that the value of work should be considered as much for the satisfaction of the worker as for the yielding of various utilizable products, I also believe that at the present time we are not in a position to consider any more than the latter aspect of our work.

Now in the case of biology teaching there is as great dissatisfaction as in any other line. One principal complains that we do not give enough information, and in the reaction against informational teaching many of us have no doubt gone too far in the direction of eliminating information. The business man concedes that the information that we do give is curious enough, but he does not see what its value is; and we must admit that it seldom happens that a business man is helped in urging people to

buy goods by knowing that insects have three pairs of legs while spiders have four. The gentlemen and ladies complain that the information about frogs and horsechestnut twigs may be interesting, but does not give culture, and a particular lady tells me that while her Eddy is just crazy to be outdoors and study flowers and bugs, he is very awkward in company and is unable to converse on literary and other genteel topics. And again other parents complain that while their children got along very well in the grammar school, and with all their teachers, they cannot make anything out of high school biology. And so from every possible point of view the results of biology teaching are not satisfactory, with the possible exception of the practical applications that may be made of the results of physiology to personal hygiene.

Apart from information, the only important product that seems to be generally advertised is a certain training or development that is supposed to result from the exercise of the so-called mental faculties, like observation, memory, reason, and so on. But the psychologists, especially those that know the most biology, are telling us, have been telling us for many years, that the faculty-psychology is all wrong, and that you cannot strengthen the "faculties" by exercise the way you can the muscles; and our own observation may tell us that the pupils do not show greater ability in the use of these faculties because of their scientific training, except in connection with the materials and ideas they have actually dealt with in their studies. We are forced, therefore, I think, to find some other justification for a continuance of our teaching, and I would direct attention to the by-products.

But when I speak of the by-products of this process I do not wish to imply at all that our primary product is of no value, or of minor or secondary value, though it may well be; I emphasize the by-products because we are in no agreement as to the primary product. What seems essential to one seems secondary to others. Under the circumstances it is necessary to catalogue the total product and then determine each for himself which he will consider the staples and which the frills, or which the main objects of his teaching and which the secondary objects. It must happen in any such cataloguing that the coördinate terms will be of very unequal value.

The first and traditional result of the educative process is knowledge. In the teaching of Biology for information, there

are a few groups of ideas, with their related ideals, that are of preëminent value.

In the teaching of Physiology, whether plant or animal, a knowledge of the fundamental processes and conditions of life in general should be a major end. The knowledge of structure should be made subsidiary, and in the study of structure the emphasis should be on the degree of adaptation to function. If in the study of adaptation of organs the pupil can be made to feel that true worth is a function of efficiency, and that efficiency is a matter of adaptation to some purpose, there will have been established an ideal that is not Biology; it is essentially ethics. I am not confusing efficiency with an ideal of efficiency; efficiency is a legitimate end of education, but I do not think we shall attain to the highest efficiency of anything but machines without this ideal; and the only study that can teach it adequately to pupils of the early high school period is, I believe, biology. But this result, though only a by-product, may not be neglected.

In the teaching of Physiology there should be developed the idea of Division of Labor, and that of the Correlation of Functions. For example, I have found it worth while to get first-year pupils to analyze a factory in their minds, to discover what the essential elements in such an establishment are. After the analysis is sufficiently complete, I ask them to tell me which is the most important factor or part of the plant. On the first impulses, many different details are mentioned by different pupils, but each suggestion is naturally met with objections from the others. I give them time to talk it out, and without any help beyond that of keeping them confined to the problem, they finally come to an agreement on the ground that where each part is essential every part is equally indispensable, and therefore equally important. The results of this analysis are then applied directly to organs or organisms under discussion. Without ignoring differences in the relative magnitude or cost or intricacy of the several processes or factors, the pupils can get a very good idea of interdependence, of equality through difference; and this idea generalized is of great value in getting an organic concept of Society as against the prevailing architectural concept. This is not biology, but it is a by-product whose value is not to be overlooked.

In the teaching of ecology there should be developed the idea that in addition to the dependence of living things upon certain

factors of the environment, there is also constantly a struggle against certain factors of the environment. The pupils should understand clearly that the struggle is against inorganic factors and against organic factors; and here again the relations between merit and fitness should be emphasized. The study of the relations of plants and animals to their environments and to each other should be supplemented by the study of the relations of plants and animals to man. And in this connection the emphasis should be not on man the merchant, buying and selling, doing business, but on man the creature that loves to live, without regard to buying and selling. In the larger cities especially does it seem to me very important to fight the prevailing commercial evaluation of the things of nature. The economic importance of plants and animals is mentioned in many of our text-books and taught by many of our teachers. But too many of our teachers, in the text-book and out, too many of our pupils, and too many of our leading citizens see in "economic importance" simply another term for "commercial availability." What is the economic importance of the crustacea? a teacher will ask, and be satisfied if the pupil remembers that the lobster industry amounts to so many million dollars, whereas the shrimps are not so important because—they are eaten only by Frenchmen. It is true that the human importance of lobsters and that of shrimps are approximately in a ratio that may be expressed in terms of the commerce in these commodities; but it is not true in general that the economic importance of any factor of our environment is commensurable with its commercial value. For example, we teach a great deal about the importance of respiration in the life of an organism, but it does not occur to us to speak of the economic importance of the atmosphere. Yet that is just what we should do, and we should place all economic references upon precisely the same basis, namely, the relation to human life and welfare. It is obvious that some of the most important things in human life and welfare have not yet been commercialized, and that the commercial test is as far removed from the human test as any well can be. Whatever, then, the pupils may forget of strophioles or echinoderms or centrosomes; whatever they may remember of angiosperms or parenchyma or trochanters, of this I believe they can never know too much or too intimately—the intricate relations that exist between the life of man and the lives of other organisms; not in the way of the sentimentalist who will go

without a drink to spare the protozoa in the water, but in the way of the master who consciously chooses, as a gardener, what he shall retain and what reject. This is not biology, it is economics—the economics of human happiness.

But in this emphasis on the human side of our subject lies a danger which it is the duty of the biology teacher to anticipate and to overcome, for nowhere else will the high school pupil have a better chance to meet it. I refer to the prevalence of the anthropocentric superstition. Every child brings this with him to school; some have lost a little of it, and some have lost more, but probably no first year high school pupil comes entirely free of it. How many pupils leave the high school entirely emancipated from it? While I would constantly emphasize the human possibilities in all the material and ideas utilized in the course, I would just as constantly knock, knock, knock against the notion that these usable and these undesirable things exist because of man. In the teaching of plant and animal physiology there is always opportunity to contrast the *function* of an organ from the point of view of the organism, with the *use* of the organ or organism from the point of view of man. To learn that the progress and welfare, yes, the very existence of man in the midst of his various needs and of the various obstacles to his satisfying his needs, are *not* the results of a world having been made for him to suit him, but are the results of man's own knowing and doing; to learn that man's mastery of his environment comes only through perpetual striving in thought and in action, is to learn something of which we cannot afford to leave any person in ignorance. Whatever else the pupil does or does not learn in school, I believe that this one by-product is of sufficient value to justify the erection of the plant; and I don't know where the pupil can more easily get the results than in the biology course. But this is not biology, it is cosmology.

One other aspect of information that should never be ignored is the teaching of the idea of evolution, with the implanting of the related dynamic ideals. And by evolution one need not mean Darwinism, nor Lamarckism, nor any other special attempt to formulate the process. But if the pupil does not get from his high school biology the evolutionary idea and the dynamic ideal, he is most likely to go out of school without these things, for I don't know where else he can get them. Certainly not from his language work, with its complex rules and interminable excep-

tions; not from that series of more or less fortunate catastrophes that is taught him under the name of history; not from the adventures and romances that constitute the bulk of his literature; only *possibly* from his mathematics, except for the fact that the laws of mathematics are so abstract and so absolute, so relentless, and, therefore, so far removed from the apparent chance and irregularity of every-day affairs, that the pupil is more likely to conclude that law is something that exists only in the text-books and in heaven. The idea of order, the idea of causality, the idea of unity, the idea of constant change, and the ideal of progress, the revolt against the doctrine, "As it was in the beginning, is now, and ever shall be," in its ordinary static sense—these things are not biology, but a valuable asset to every person, and a possible by-product of biology teaching.

Biology has borrowed from social science three ideas that have influenced its development profoundly. The idea of Evolution, the idea of Division of Labor, and the idea of Struggle for Existence have been thus borrowed, with what results we all know. It is the duty of teachers of Biology to return to society these ideas, with compound interest of broadened application and fuller, more definite content.

* * * * * *

If we reject the faculty-psychology, as we must, we need not reject with it whatever benefits may accrue from the formation of useful habits. The method of the laboratory has been lauded for its remarkable effects upon the character of its devotees—or victims—and much has no doubt been credited to the laboratory that properly belongs elsewhere. But I think there can be no question as to the value of saying clearly and exactly what one means. If the laboratory is not the only place where this habit may be acquired, it is for the high school pupil the place where he can get the greatest amount of practice in this exercise, and under the most valuable control, the control, that is, of the objective limitations to the thoughts he is trying to express. Indeed, I sometimes think that too large a share of our teaching time is taken for doing the work that should be divided among all the departments of the school and which, it sometimes seems, is most systematically neglected by the English departments. The especial advantage of doing language work in connection with the objective material is generally recognized. At the same time we may be tempted to overestimate the importance of getting from

each pupil a complete and accurate statement of what he has seen or thought. While we may be sure, when the pupil makes such a satisfactory statement, that he has seen that of which he speaks, we may *not* be sure, when the pupil can neither describe nor draw nor model that which he is supposed to have seen, that he does *not* understand it. And this for the very simple reason that not only does expression follow impression, but it often follows at a very respectful distance. Every one of us knows that in the efforts to learn a foreign language, a stage is reached at which one is quite able to understand a rather long and complex sentence, without being able to formulate correctly a much simpler sentence in the foreign tongue. It may be the same with our pupil; he understands a great deal more than he is able to tell, and the difficulty of the teacher is to know when the pupil *understands* without waiting until the pupil can also *tell* what he understands. Yet if we have to wait for the telling, we have a by-product of great value. But this is not biology, it is expression, graphic or linguistic.

And the expression learned in the laboratory has the recognized advantage that it operates under conditions that permit of immediate and constant objective control as to accuracy and adequacy. I am not sure that science teaching does, as is often claimed, inculcate a love of truth. But I do feel sure that science teaching may impart a keen realization that there is a difference between truth and error which is quite independent of opinion or authority. It may perhaps stimulate in some cases a languid self-reliance. If the question the pupil is moved to ask by a suggestion from the material with which he works is promptly and satisfactorily answered by the teacher, there is great saving of time for the teacher, there is great increase of knowledge for the pupil, and everybody is happy—except a few cranks. For the more the pupil gets information by the mere asking from his teacher, the longer will it take him to learn that the only way the teacher found out was by looking at the material or by reading what some other looker had written; the longer will it take him to realize that he can find out more directly and more certainly without asking; the longer will it take him to throw off the superstitious awe for the authorities that have acquired their wisdom in some mysterious way supposedly beyond his reach. It is not necessary that the pupil be left with his specimen and his own resources "to observe," but it is necessary that no opportunity

be lost to teach the pupil that most of the questions he asks he can answer for himself; to teach him that the opinions of men and women are worth just in proportion as they are founded on sound knowledge and on sound inference. To teach one that his own brain with its peripheral organs is an apparatus that can create knowledge as well as that of the writer of text-books, and to develop a habit of looking to this apparatus for first aid, instead of the habit of asking someone else—that is not teaching Biology, it is teaching self-reliance in thinking; and this by-product alone is worth the price of admission.

But it is not enough to think boldly and independently; it is necessary also that the thinking be logical and coherent. The study of grammar is under certain conditions nothing but the study of logic, but it is so formal and so attenuated and so much restricted by the special rules, that it is very uncertain, in regard to the pupils who attain high ratings in grammar, whether they are those who were better thinkers before they began the study, or those who acquired the art during the course of the study. On the other hand, the logic of the laboratory, like the expression of the laboratory, is constantly subject to the external, impersonal check. The method of the experiment leaves no room for opinion where certainty is possible. We hear it often objected that the method of science, meaning the method of thought in science, is all right for those who are to pursue the study of science further, but is of no use to the pupils who leave the high school at the end of one or two years. From this view I must dissent, and for the following reasons:

The pupil that becomes a scientist does so only on condition that he is prepared to meet his problems, prepared, that is, to think as a scientist. But the student that goes into the shop or the factory or the office without any more schooling than he gets by the end of the first or second year of high school, is still to become a citizen and a worker, and it is especially from the point of view of the citizen, who is called upon without any special preparation to declare periodically what shall or shall not be the policy of his city or state, and who shall or who shall not be entrusted with carrying out the will of the people, that the method of science can be of tremendous value. The habit of analyzing complex phenomena is of value to every man and to every woman that has to live in an environment complex enough to support human life. This habit is to be acquired only through the prac-

tice of analyzing complex phenomena, and will be regularly exercised only where there is a live realization that phenomena *are* to be analyzed. And nowhere in the school course is there presented an opportunity for such analysis, or for realizing its importance, like that furnished by biology teaching. Very few of the pupils that enter high school ever get a chance to study economics or any other branch of social science; yet every young person that lives long enough is expected to have opinions on the most complex problems, and that, too, when most people are not even aware that there is such a thing as analyzing a problem. They have heard of analyzing water from a suspected well or of analyzing adulterated food; but they don't know anything at all about analyzing the tariff question or the open shop question or the equal pay question. Of course I do not refer to the fact that they do not use the word "analyze" in this connection, but to the fact that they do not realize that there is such a process and that it must be applied to every question. Now I do not claim that the study of biology will make our pupils competent to pass sound judgments upon the public problems that confront the citizen, but I do claim that a habit of analyzing complex problems, the habit of looking for the factors or elements, is a decided advantage in meeting such problems, and this habit our course might establish more or less firmly, by our calling attention to the function of analysis in the activities of the physician or the engineer or the statesman, and to its function in the solution of the thousands of problems that arise in the practical conduct of each individual's affairs. This idea of analysis and the habit of analysis are of great value, but they are not specially biological.

In this connection our old friend, the faculty of observation, deserves a brief notice. It is quite certain that the practice in the observation of flowers and bugs does not establish the general habit of observing everything that comes within the range of our senses. But it is equally certain that a realization of the importance of certain classes of facts will make one both diligent and careful in the gathering of those facts. Now we can make the pupil realize that a knowledge of facts is essential to the solution of various problems, and that the facts are worthless unless they are the results of careful, accurate observation. Beyond that we can only make him familiar with types of structures in which he will discover details and variations more readily after practice; we can never teach a boy to take in at a glance his sis-

ter's new millinery dream by the application of the laboratory method to the inside of a crayfish.

All these methods of science, analysis, observation, inference and verification, will not become fixed habits of pupils unless a special effort is made to generalize their applications to the affairs of the trades and the professions and the interests of every-day life; and Biology furnishes the best basis for such generalizations, being on the one hand complex enough to be safe for analogies to practical affairs, and being on the other hand concrete enough to allow of objective and experimental study.

One might be tempted to ask whether I would teach anything in the biology course that is really biological, or whether I would leave anything for other departments of a school to do. To answer the latter question first, I would say that I believe that every subject in the school must contribute its share towards the inculcating of certain ideals, towards the establishment of certain habits of thought and action, and towards proficiency in the arts of expression or communication, in addition to the imparting of information proper to its department. That there are biological matters to be taught in the biology course goes without saying, but these other things to which I have referred are some of the by-products, actual or potential; and we cannot afford to ignore them.

To summarize, I should like to present this plan or ideal for utilizing the by-products of biology teaching:

Teach for thinking, as against merely remembering or believing.

Teach to think straight rather than loosely or crookedly.

Teach to think to some purpose, rather than diffusely, vaguely.

Teach to think to some human purpose, as against merely personal or commercial purpose; and finally—

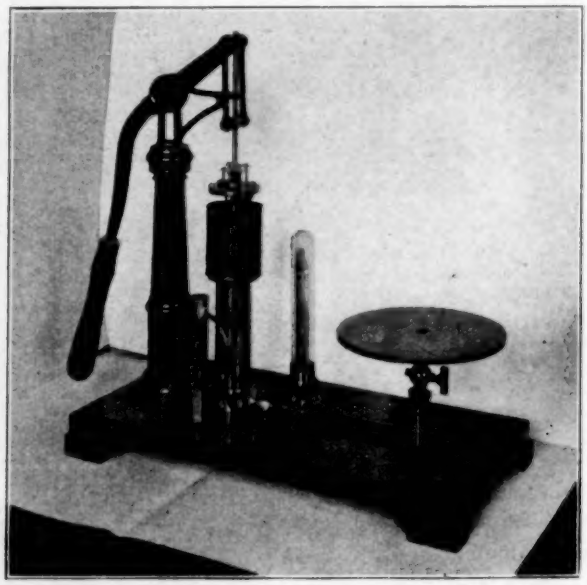
Teach for an ideal of a dynamic human purpose, as against a static one.

TO REMODEL AN OLD STYLE AIR-PUMP.

By Harrison H. Brown,

Pratt Institute, Brooklyn.

Most laboratories contain one or more air-pumps of the old-fashioned mechanical type, which are either incapable of effective use, or become so very soon after renovation. This article describes an inexpensive method of modifying an old Queen pump which requires only the simplest machine work and may be undertaken by any instructor at all familiar with the use of tools. The pump will be in readiness for instant use after standing any length of time.



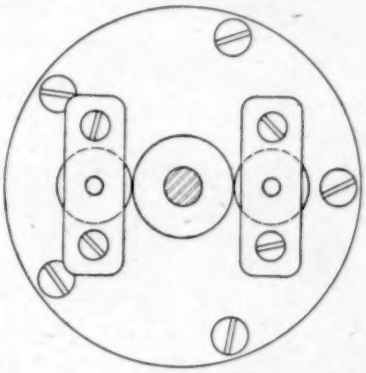
The pump is stripped by the removal of the pump plate, top of barrel, and plunger, and the pump barrel and exhaust pipe taken off from the base.

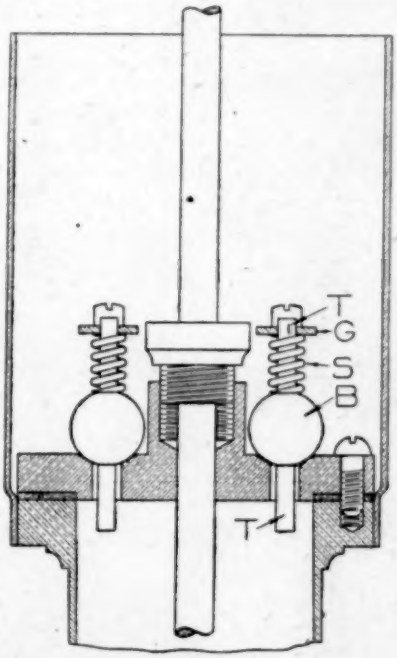
The exhaust pipe, or connection to the pump plate, is now sawed off close to the barrel, and the end of the exhaust pipe is closed by sweating in a piece of brass rod, R—which is left projecting nearly a quarter of an inch.

A copper cuff A four inches high is soldered to the top of the pump barrel to form an oil reservoir. This cuff is made larger

than the top of the pump barrel as shown, except where it is soldered on, in order that the top of the pump may be readily replaced. If the screws which held the top on go right through the flange, they will be closed by the screws when the top is again in place.

The barrel has now one hole at the bottom where the pump plate connection was sawed off. A second hole is to be drilled exactly above the first and about one and one fourth inches from it to receive a piece of one fourth inch soft copper tube. The lower edge of the hole should not be over five sixteenths inch above the top of the plunger when it is as far down as it will go. The lower hole is bored to same size. Short pieces of tubing say 1¼ inches long are soldered into these two holes, care being taken to leave the inside of the barrel smooth and unobstructed. A piece of ¾ inch brass pipe the length of the pump barrel is drilled to correspond with these two holes, and another hole of the same size is drilled 90 degrees away, and near the other end of the pipe, which is to be the top. The open ends of the pipe are closed by brass plugs sweated in. This pipe is joined to the pump barrel by soldering the two short tubes into the holes drilled for them.





The barrel and auxiliary pipe are now placed on the wooden base with the hole in the top of the auxiliary pipe facing the pump plate. It remains to mark the position of the plugged end of the pump

plate connection and drill a blind hole for its reception. There is usually a squared fitting near this point carrying a screw to admit air after exhaustion; if so, it should be drilled on the proper side for a one-fourth inch soft copper tube whose other end goes into the top of the auxiliary pipe. This tube having been shaped by hand, the whole is strongly soldered together and fastened as before on the wooden base.

There remain the valves in the top of the pump-barrel. They are simple ball valves made from commercial brass balls five-eighths inch in diameter, and bored centrally for five thirty-secondths inch brass rods, T T, which are sweated in place. These rods are long enough to project one-fourth inch into the barrel. The round holes drilled through the top are three-eighths inch in diameter, and countersunk at the upper side by a sixty degree drill. The balls are held in place by the very simple guides shown, and held in their seats by the spiral springs S S. It will be well to leave the brass rods T T an inch longer than shown until the valves have been ground in by oil and fine emery. The grinding can be done by an ordinary ratchet drill stock.

When the apparatus is reassembled, the leather packing is to be rotated one hole from its former position, and the top a hole or two more, so that the old passage for the escape of exhausted air shall be closed.

Half a tumbler of an easily flowing but non-volatile machine oil is poured into the reservoir, and the pump is ready for use.

The rods T T which project into the barrel do not allow the valves to close when the plunger is at the top of the stroke till enough oil is admitted below to act as a seal of the plunger, and to fill the clearance space at the top of the next stroke.

Do not hurry the pump when beginning exhaustion or at the top of the stroke at any time. The only precaution necessary is to keep grit out of the valves. With a pump modified in this way the writer has frozen water by evaporation. Even when the heavier parts of the soldering are done by a tinsmith the total expense may be under three dollars.

PROBLEM DEPARTMENT.

IRA M. DELONG,

University of Colorado, Boulder, Colo.

Readers of the Magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Problems and solutions will be duly credited to their authors. Address all communications to Ira M. DeLong, Boulder, Colo.

Algebra.

82. *Proposed by W. T. Brewer, Quincy, Ill.*

Solve, $x^2 + y^2 + xy = 19$ ..... (1)

$x^2 + z^2 + xz = 13$ ..... (2)

$y^2 + z^2 + yz = 7$ ..... (3)

Corrected answer by the proposer.

x	y	z
3	2	1
-3	-2	-1
$\frac{7}{3}\sqrt{3}$	$\frac{1}{3}\sqrt{3}$	$-\frac{8}{3}\sqrt{3}$
$-\frac{7}{3}\sqrt{3}$	$-\frac{1}{3}\sqrt{3}$	$\frac{8}{3}\sqrt{3}$

92. *Proposed by H. E. Trefethen, Kent's Hill, Me.*

Two men engage to build twenty rods of stone wall. The stones are all in a pile at one end, and they agree that it is as much work to move the stones as to lay the wall. A begins at the pile of stones and B at the other end. How many rods ought each to build to do half the work?

Solution by A. W. Rich, Worcester, Mass.

Let x = number of rods A builds, y = number B builds, then $x + y = 20$. Let m = work required to build one rod, then $20m$ = entire work required to build the wall. Let n = work required to move one rod of stone one rod, then the work of moving the 20 rods of stone (on the average of 10 rods each) $= 200n$. From this $20m = 200n$, or $m = 10n$.

mx = work A does in building, $\frac{nx^2}{2}$ = the work A does in moving stone, and $mx + \frac{nx^2}{2}$ = A's total work.

my = work B does in building, $n\left(xy + \frac{y^2}{2}\right)$ = work B does in moving stone, and $my + n\left(xy + \frac{y^2}{2}\right)$ = B's total work.

We have now the relations, $x + y = 20$

$$m = 10n$$

$$mx + \frac{nx^2}{2} = my + n\left(xy + \frac{y^2}{2}\right),$$

from which we find $x = 12.36$ and $y = 7.64$.

[NOTE.—The length of the wall is divided in extreme and mean ratio. —E. L. BROWN.]

Geometry.

93. *Proposed by O. S. Hoover, Laton, Cal.*

If from the vertices of any triangle straight lines be drawn to the points where the inscribed circle touches the sides, these lines are concurrent (Ex. 20, page 274, Ray's Geometry and Trigonometry). A proof without using Ceva's Theorem preferred.

Solution by E. L. Brown, M.A., Denver, Colo.

Let the circle be tangent to the sides BC, CA, AB at the points D, E, F respectively. Join AD, BE, CF. Let CF intersect AD in O. Through F draw a line parallel to AD, intersecting BC in G.

Let $l = AE = AF$, $m = BF = BD$, $n = CD = CE$, $x = DG$.

From the similar triangles BFG and BAD, we have

$$OD : FG = n : (n + x) \quad \ldots\ldots (1).$$

From the similar triangles BFG and BAD, we have

$$FG : AD = m : (m + l) \quad \ldots\ldots (2).$$

Since FG is parallel to AD, we have

$$x : l = m : (m + l) \quad \ldots\ldots (3).$$

From (1), (2), and (3), we have

$$OD = AD \frac{mn}{l(m + n) + mn}.$$

Since m and n are similarly involved, BE will pass through the point O.

94. *Proposed by I. N. Warner, Normal, Ill.*

Upon the given line AB construct a regular pentagon.

Solution by Irwin E. Kline, Blairstown, N. J.

Construct an angle equal to one-fifth of a perigon, as follows: Divide any line O_1A_1 internally in extreme and mean ratio at P_1. Draw at M the perpendicular bisector of O_1P. With P as a center and radius PA_1 describe an arc cutting this bisector in B_1. Then B_1O_1P is $^1/_5$ of a perigon.

Proof: $O_1P \cdot O_1A_1 = PA_1^2$, $O_1A_1^2 + O_1B_1^2 = A_1B_1^2 + 2O_1M \cdot O_1A_1$,

$2O_1M \cdot O_1A_1 = O_1P \cdot O_1A_1 = PA_1^2$,

$\therefore$ $O_1A_1 = A_1B_1$, and angle $B_1O_1A_1 = A_1B_1O_1 = O_1PB_1 = 2PA_1B_1$.

$\therefore$ $B_1O_1A_1$ is $^2/_5$ of a straight angle or $^1/_5$ of a perigon.

On AB as a chord construct a segment of a circle containing an angle equal to B_1O_1P, erect the perpendicular bisector of AB and where it intersects the arc of the segment containing the given angle will be the center O of the required pentagon. Divide the perigon O into five equal parts and describe a circle with O as center and OA as radius. Obviously the required regular pentagon is constructed.

Approximate construction by I. N. Warner, Normal, Ill.

Using A and B as centers and AB as a radius, draw two circles whose circumferences shall intersect as at M and N. Draw the common chord MN. Using N as a center and the same radius as before, draw a third circle whose circumference shall intersect the first two at X and Y respectively, and MN in O. Draw the straight lines XO and YO, and extend them to cut the opposite circumferences at C and E. Then A, B, C, E are four of the points of the pentagon, and the fifth vertex D is located by means of the compass and the radius AB.*

[*In this construction, angle EAB = CBA = 108° 22′.—Ed.]

95. *Proposed by I. L. Winckler, Cleveland, Ohio.*

Construct a triangle, having given the base, the line bisecting the vertical angle and the diameter of the circumscribing circle.

Solution by A. J. Lewis.

Let $a = \frac{1}{2}AB$ (the base), $b = EC$ (the bisector), S the middle point of the arc AB, $d = SD$ (the perpendicular from S to AB), $y =$ the distance from S to the point E where the bisector intersects the base, and $x = DE$.

$$by = (a + x)\ (a - x), \text{ or } by = a^2 - x^2 \ldots\ldots\ldots\ldots\ldots (1).$$

$$x^2 = y^2 - d^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2).$$

Substituting in (1), $by = a^2 - y^2 + d^2$, whence

$$y = \frac{-b + \sqrt{b^2 + 4a^2 + 4d^2}}{2}$$

(the negative sign being obviously excluded).

Therefore if a right triangle is constructed, with sides $a + d$ and $\frac{b}{2}$, its hypotenuse minus $\frac{b}{2}$ gives the length of y. With y as a radius and S as a center describe an arc cutting AB in E. Draw SE and produce it to C in the circumference. ABC is the required triangle.

Trigonometry.

96. *Proposed by H. E. Trefethen, Kent's Hill, Me.*

In a plane triangle given

$b = a \sin C$ and $c = a \cos B$.

Find all the angles.

Solution by Geo. W. Hartwell, Columbia University, N. Y.

From $b = a \cos C \ldots (1)$, $c = a \cos B \ldots (2)$ and the Law of Cosines, $\cos B = \frac{a^2 + c^2 - b^2}{2ac} \ldots (3)$, we have, $\frac{c}{a} = \frac{a^2 + c^2 - b^2}{2ac}$, and therefore, $a^2 = b^2 + c^2$, $\therefore A = 90°$. By the Law of Sines, $\frac{a}{\sin A} = \frac{c}{\sin C}$, and since $A = 90°$, $a \sin C = c \ldots (4)$. From (1) and (4) we have $b = c$. $\therefore$ $B = C = 45°$.

Miscellaneous.

86. *Proposed by Ira P. Baldwin, Emporia, Kansas.*

A bather, standing on the bank of a circular pond three miles in circumference, wishes to reach the point directly opposite in the shortest time possible. If he can swim at the rate of 5 miles an hour and run at the rate of 6 miles an hour, what point must he swim toward?

Corrected solution by Eugene R. Smith, Montclair, N. J.

Using the same figure as Mr. Brown, on page 144, where A is the starting point, D the point diametrically opposite, and C the point toward which he swims, we may designate the angle DAC by ϕ, then

$$t = \frac{2R}{rr'}, (r' \cos\phi + r\phi).$$

$$\frac{dt}{d\phi} = \frac{2R}{rr'}, (-r' \sin\phi + r), \frac{d^2t}{d\phi^2} = \frac{2R}{rr'}, (-r' \cos\phi) = -\frac{2R \cos\phi}{r}.$$

Let t_0 be the value of t when $\phi = 0$, and t_1 the value when $\phi = \frac{\pi}{2}$ then $t_0 = \frac{2R}{r}$; $t_1 = \frac{\pi R}{r'}$, and t_0 is greater than, equal to or less than t_1 according as r' is greater than equal to or less than $\frac{\pi r}{2}$. The diameter is thus the minimum as long as the land rate is less than $\frac{\pi}{2}$ times the water rate. There are two equal values when the land rate equals the water rate, and the semicircle becomes the minimum path when the land rate is more than $\frac{\pi}{2}$ times the water rate.

97. *Proposed by W. L. Malone, Fern Hill, Washington.*

A courier and a bather start at the same time from the same point on the bank of a circular pond, radius r, the one to run round the pond at the rate of a miles per hour, the other to swim at the rate of b miles per hour $(a > b)$. Toward what point must the bather swim so as to arrive at the same time as the courier, and how far will each have traveled?

Solution by I. L. Winckler, Cleveland, Ohio.

Suppose A is the starting point and C the point at which they meet. Draw the diameter AB. Let ABC $= \Theta$, then AC $= 2r\sin\Theta$, and arc AC $= 2r\Theta$.

Time of courier and time of bather being equal, $\frac{2r\Theta}{a} = \frac{2r\sin\Theta}{b}$, or

$$\frac{b}{a} - \frac{\sin\Theta}{\Theta} = 1 - \frac{\Theta^2}{3!} + \frac{\Theta^4}{5!} - \frac{\Theta^6}{7!} + \ldots.$$

Let $b/a = x$ and $\Theta^2 = y$, then $x = 1 - y/3! + y^2/5! - y^3/7! \ldots\ldots$

Reverting this series we obtain

$$y = 6(1-x) + {}^9/_5(1-x)^2 + {}^{99}/_{175}(1-x)^3 + \ldots\ldots\ldots\ldots$$

Since $\Theta = \sqrt{y}$, the distance which the bather goes,

$$2r\Theta b/a = \frac{2rb}{a}\sqrt{6\left(\frac{a-b}{a}\right) + \tfrac{9}{5}\left(\frac{a-b}{a}\right)^2 + \tfrac{99}{175}\left(\frac{a-b}{a}\right)^3 + \ldots.}$$

and the distance the courier goes is

$$2r\sqrt{6\left(\frac{a-b}{a}\right) + \tfrac{9}{5}\left(\frac{a-b}{a}\right)^2 + \tfrac{99}{175}\left(\frac{a-b}{a}\right)^3 + \ldots.}$$

CREDIT FOR SOLUTIONS RECEIVED.

Algebra 73. Wm. B. Borgers. (1)

Algebra 82. W. T. Brewer. (1)

Miscellaneous 86. Eugene R. Smith, H. E. Trefethen. (2)

Algebra 87. Lloyd Holsinger, J. F. Lawrence, L. R. Odell, Eugene R. Smith. (4)

Algebra 88. J. F. Lawrence, Eugene R. Smith. (2)

Geometry 89. Jesse V. Buck, Lloyd Holsinger, Irwin E. Kline, J. F. Lawrence, Eugene R. Smith. (5)

Geometry 90. J. F. Lawrence, Eugene R. Smith. (2)

Miscellaneous 91. Eugene R. Smith. (1)

Algebra 92. E. L. Brown, Walter L. Brown, R. P. Harker, Geo. W. Hartwell, O. S. Hoover, J. F. Lawrence, A. J. Lewis, W. L. Malone, A. W. Rich, H. E. Trefethen, I. L. Winckler, G. B. M. Zerr. (12)

Geometry 93. E. L. Brown, A. J. Lewis, Eugene R. Smith, H. E. Trefethen (3 solutions), I. L. Winckler (2 solutions), G. B. M. Zerr. (9)

Geometry 94. E. L. Brown, Geo. W. Hartwell, Irwin E. Kline, A. J. Lewis, Marjorie O'Connell, A. W. Rich, O. R. Sheldon, Eugene R. Smith, H. E. Trefethen, I. N. Warner, I. L. Winckler, G. B. M. Zerr. (12)

Geometry 95. E. L. Brown, Walter L. Brown, C. S. Cory, Geo. W. Hartwell, O. S. Hoover, A. J. Lewis, Eugene R. Smith, O. R. Sheldon, H. E. Trefethen (2 solutions), C. E. Wheeler, I. L. Winckler, G. B. M. Zerr. (13)

Trigonometry 96. E. L. Brown, Walter L. Brown, Geo. W. Hartwell, O. S. Hoover, A. J. Lewis, Eugene R. Smith, O. R. Sheldon, H. E. Trefethen, I. L. Winckler, G. B. M. Zerr. (10)

Miscellaneous 97. E. L. Brown, Walter L. Brown, A. J. Lewis, O. R. Sheldon, H. E. Trefethen, I. L. Winckler, G. B. M. Zerr. (7)

Total number of solutions, 81.

PROBLEMS FOR SOLUTION.

Algebra.

99. *Proposed by Saul Epsteen, Boulder, Colo.*

Express $(x - a_1)(x - a_2) \ldots\ldots (x - a_n)$ as a determinant of the $n + 1^{\text{th}}$ order with monomial elements.

103. *Proposed by J. J. Browne, Colorado School of Mines, Golden, Colo.*

Factor: $(la' + l'a)^3 (bc' - b'c)^3 + (lb' + l'b)^3 (ca' - c'a)^3 + (lc' + l'c)^3 (ab' - a'b)^3$.

104. *Proposed by I. L. Winckler, Cleveland, Ohio.*

A company of n men were counting their money. The first said to the second, "Give me your money and I will have a dollars." The second said to the third, "Give me one-half of your money and I will have a dollars." The third said to the fourth, "Give me one-third of your money and I will have a dollars."..... The nth said to the first, "Give me one-nth of your money and I will have a dollars." What sum had each?

Geometry.

105. *Proposed by Chas. Jenney, Hingham, Mass.*

Let the sides of a triangle ABC be divided into m equal parts. Call the nth point of division from A on AB, F, the nth point from B on BC, D, and the nth point from C on CA, E. Draw DE, EF, and FD.

Now divide each side of DEF into m equal parts. Call the nth point from D on DF, G, the nth point from F on FE, H, and the nth point from E on ED, K, and draw GH, HK, and GK. Then the sides of GHK are parallel respectively to the sides of ABC.

Miscellaneous.

(I hereby offer a prize of three dollars for the best solution of the following problem. Address all solutions to Ira M. DeLong, Boulder, Colo.—O. R. SHELDON, Chicago, Ill.

A magician asked his audience to announce in order the three remainders resulting from the division by 7, 5, and 3 of any integer from 1 to 100. He claimed to be able to tell without a moment's hesitation what integer was used. How could he do this?

NOTICE.

The supply of reports of the Committee on Geometry in the hands of the secretary of the mathematics section of the C. A. S. M. T., Miss Mabel Sykes, is exhausted.

REDWOOD CANYON DEEDED TO UNITED STATES.

A most public-spirited gift to the nation has come from William Kent of Chicago, who has just deeded to the United States 295 acres of primeval redwood forest on the southern slope of Mount Tamalpais, about six miles from the city of San Francisco. The land was deeded to the Government with the approval of Mr. Pinchot, Chief of the Forest Service. The papers have now gone to the Secretary of the Interior, and a proclamation declaring the canyon a National Monument will be signed at an early date.

This means that more of California's redwood giants will be saved for the scientific study and pleasure of the whole country, in fact, for the whole world, for the great sequoias are found nowhere except in the Golden State. This grove, given to the Government by Mr. Kent, is one of the few tracts of redwood forest to be found in the natural state in California to-day. The land is said to have cost Mr. Kent $47,000 some years ago, but its stand of redwood timber alone is now valued at more than $150,000 on the market, beside other timber worth $50,000.

The canyons of Tamalpais which drain into San Francisco bay were cut clean years ago, and the redwood obtained from them went into the construction of the old San Francisco. The giants on this tract escaped the axe, however, chiefly because the outlet is on the ocean side, instead of the bay side, and also because the various owners of the land have, for sentimental reasons, jealously guarded the timber from harm or destruction.

It is the intention to name this National Monument the Muir Woods, after John Muir, the noted naturalist.—*Forestry and Irrigation.*

SCIENCE QUESTIONS.

By Franklin T. Jones.

University School, Cleveland, Ohio.

Propose questions for solution or discussion.
Send in solutions of questions asked.
Send examination papers in the sciences.

This is in answer to the question in the January number of School Science and Mathematics: To what height would a person have to rise above the earth's surface to observe its revolutions, providing it was possible to see so far?

Assuming that "revolution" means rotation on its axis, and that "stationary" means fixed with reference to the stars, I believe the observer would need no greater elevation than the thickness of a sheet of paper in order to be convinced that "the world do move." But he would need considerably more elevation to escape danger from trees, sky-scrapers, etc., approaching him, in this latitude of New York, at the rate of more than eighteen miles per minute. He would also find the atmosphere of the earth rushing past him, creating—for him—a breeze of 1,000 miles an hour.

Yet, again, if we are to consider the revolution of the earth around the sun, and the observer started to get off the earth in front, that is, on that side of the earth that faces in the direction of the earth's flight through space, he would not have to go more than an inch to find the earth immediately coming towards him. But he might have to go a long way in a straight line in order, at length, to get "off the track" of the earth and let it go flashing past at the rate of 111 miles per minute. W. M. Bennett.

Rochester, N. Y.

Proposed by John J. Farrell, South Norwalk, Conn.

There is a train of flat cars one mile long traveling at a rate of one mile a minute. A man stands on the front end and also one on the rear end who has a rifle that will shoot a ball at a rate of one mile a minute. When he shoots at the man on the forward end will the bullet reach him or not?

HOW TO OBTAIN EXAMINATION QUESTIONS.

Examinations do not prove whether a pupil has profited or not by his course of study, but they do afford a reasonable test as to his mastery of the fundamentals of the subject and his ability to reproduce knowledge gained. Sometimes the fact that examinations cannot test attainment perfectly is advanced as an argument for abandoning them altogether. The fallacy of this argument is self-evident.

Because many teachers are desirous of testing their pupil's knowledge and attainment as completely as possible, and because the college

entrance examinations are the best available questions for this purpose, the manner in which they may be obtained is given below:

The College Entrance Examination Board: Address Ginn & Co. for circular.

Bryn Mawr College, Bryn Mawr, Pa. Pamphlet containing the June examinations of a single year; cost, 30 cents.

Case School of Applied Science, Cleveland, Ohio. Pamphlet free.

Cornell University, Ithaca, N. Y. Pamphlet ready about April 1, free.

Harvard University, Publication Office, Cambridge, Mass. Pamphlet containing the June examinations of a single year, free. Copies of any single paper, six for five cents.

Massachusetts Institute of Technology, Boston, Mass. Pamphlet free.

Princeton University, Princeton, N. J. Pamphlet free.

New York State Education Department, Albany, N. Y. Papers, 50 cents per 100. Pamphlet, 25 cents.

Sheffield Scientific School, New Haven, Conn. Pamphlet free.

Yale College, New Haven, Conn. Pamphlet free.

Other institutions as University of Pennsylvania, Columbia, Williams, Amherst, Dartmouth, etc., also publish pamphlets which may be obtained on application.

PLATINUM.

The production of platinum in the United States in 1904 was 200 ounces, valued at $4,160; in 1905 the production was 318 ounces, valued at $5,320; in 1906 the platinum production of the country amounted to 1439 ounces, valued at $45,189, a fourfold increase in quantity and more than eightfold increase in value over the figures for 1905.

The principal feature of interest in the platinum industry during the year was the phenomenal rise in prices for ingot platinum, which, beginning with $20.50 per troy ounce on January 6, 1906, had on November 17 reached $38.00, remaining at this figure until the end of the year, after which there was another slight rise in price. In February, 1907, for the first time, a distinction was made between ordinary platinum and hard platinum, that is, platinum rich in iridium and osmium, considerable iridium being allowed to remain alloyed in the platinum of the ingots. Such hard platinum was quoted at $41 per ounce on February 23, and this price held until April 6, 1907, when the placing on the market of more than 100 pounds of platinum by a new producer interested in American developments checked the advance, and on May 4, 1907, ordinary platinum was quoted at $32 and hard platinum at $35. Then a gradual decline set in and the present price (October, 1907) in $23 for ordinary and $25 for hard platinum.

In presenting statistics of the platinum industry in 1906 in an advance chapter from "Mineral Resources of the United States, Calendar Year 1906," Dr. David T. Day, of the United States Geological Survey, quotes an article by S. I. Gulishambarov, of the Russian ministry of finance, translated in the Mining Journal (London), summarizing reasons for

the remarkable advance in prices, and a paragraph from that article is requoted here:

"In the twenties of the last century, after the discovery of platinum in the Ural Mountains, the world's output of the metal, according to data collected by the Russian minister of finance, amounted to 40 poods [a pood equals a trifle over 36 pounds] per annum. The demand for it was, however, so small that the Government had to take steps to find a sale for it and began buying it on its own account for coinage. In the sixties of the same century the development of the chemical industries in western Europe, and later the springing up of electrical engineering and the dental manufacturing business increased the uses of platinum, but in spite of this the supply was still in excess of the demand."

All this has since changed. Statistics show that the United States, France, Great Britain, Germany, and Russia require annually quantities of the metal much larger than are produced, and the present high price is the legitimate result of natural conditions of supply and demand.

The manner of occurrence of platinum in the United States and elsewhere, the methods of its extraction, its physical properties, and its uses were summarized by F. W. Horton in a paper in the Mineral Resources of the United States for 1905.

In the report for 1906 Dr. Day, whose work for the Geological Survey in connection with the experiments on the black sands at Portland, Oreg., has done so much to develop platinum mining in the United States into a permanent and profitable industry, calls special attention to the platinum placers of the South American Republic of Columbia, which next to Russia is the most important producer of the mineral.

During 1906 a new concentrating apparatus to use the black sands was installed for the placer interests near Cariboo, Canada, and it is probable that this plant will yield a considerable output in 1907.

The occurrence of platinum in copper-nickel ores in southwestern Utah and eastern Nevada has also been reported, and two companies have begun development work on low-grade copper-nickel ores in the northeastern part of Lincoln County, Nev.

It is interesting to note that the imports for consumption of platinum during the calendar year 1906 were valued at $3,788,759, as against $2,173,623 in 1905 distributed as follows: Unmanufactured, 1267 pounds, valued at $390,989; ingots, bars, sheets, and wire, 10,227 pounds, valued at $3,210,131; vases, retorts, and other apparatus, vessels, and parts thereof for chemical uses, $186,398; manufactures of, not specially provided for, $1,241.—*U. S. Geological Survey Bulletin.*

MICHIGAN SCHOOLMASTER'S CLUB.

The spring meeting of this club will be held at Ann Arbor, April 1-3. Separate sections in Physics, Chemistry, Biology, and Mathematics. An interesting and instructive program has been prepared. All teachers of science and mathematics in Michigan should attend.

ARTICLES IN CURRENT MAGAZINES.

Biological Bulletin for February: "The Annulus of a Mexican Crayfish," E. A. Andrews; "Some Further Records Concerning the Physiology of Regeneration in Tubularia," T. H. Morgan; "The Cause of the Production of 'Down' and Other Down-like Structures in the Plumages of Birds," Oscar Riddle.

Botanical Gazette for January: "The Development of the Pollen of Sarracenia," M. Louise Nichols; "Embryogeny of Arisaenia Triphyllum," James E. Gow; "The Toxic Effect of Certain Common Salts of the Soil on Plants." Florence N. Magowan.

Entomological News for March: "Argynnis Astarte, Doubl.—Hew., and Other High Mountain Butterflies," F. H. Wolley; "Notes on Catocala," R. R. Rowley; "Winged Aphids," C. W. Woodworth.

Journal of Geology for January-February: "Linosa and Its Rocks," Henry S. Washington; "The Variations of Glaciers," Harry F. Reid; "Flaxman Island, a Glacial Remnant," Ernest De Koven Leffingwell; "Causes of Permo-Carboniferous Glaciation," W. M. Davis.

Mining Science for February 6: "The Future of Copper and the Scarcity of Gold." For February 27: "A Historic Sulphur Mine in Durango, Mexico," Douglas Muir.

Nature-Study Review for January: "The Relation of Nature-Study and Science," C. F. Hodge, S. Coulter, C. R. Mann, M. A. Bigelow; "Naturalists' Outlook and School Nature-Study," E. F. Bigelow.

Physical Review for January: "Conditions Affecting the Discharge of Electrodes in Phenomena of Ionization," J. G. Davidson; "On the Density, Electrical Conductivity, and Viscosity of Fused Salts and their Mixtures, II," H. M. Goodwin and R. D. Mailey; "The Change of Phase Due to the Passage of Electric Waves Through Thin Plates and the Index of Refraction of Water for Such Waves, with Applications to the Optics of Thin Films and Prisms," Wm. R. Blair; "The Viscosity of Water at Very Low Rates of Shear," L. E. Gurney; "Some Observations on the Surface Rigidity of Water," L. E. Gurney; "Effects of the Soluble Constituents of Glass on the Viscosity of Water at Very Low Rates of Shear," L. E. Gurney; "The Stability of Cadmium Cells," Henry S. Carhart. For February: "The Discharge of Electricity from Pointed Conductors," John Zeleny; "The Fluorescence and Absorption of Anthracene," Louise Sherwood McDowell; "The Heat Dilution of Aqueous Salt Solutions," F. L. Bishop; "The Relation Between 'Potential Temperature' and 'Entropy,'" L. A. Bauer; "Proceedings of the American Physical Society."

Popular Astronomy for March: "An Astronomical Theory of the Molecule and an Electronic Theory of Matter," Severinus J. Corrigan; "A Night Mirage," William E. Sperra; "Some Opportunities for Astronomical Work with Inexpensive Apparatus, II," George E. Hale.

Popular Science Monthly for February: "A Visit to the Hanchow Bore," Dr. Charles Keyser Edmunds; "The Relation of Color to Chemical Constitution," Dr. William J. Hale; "German Influence in Latin America," Alfred F. Sears; "The Problem of International Speech," Anna Monsch Roberts; "Infant Industries," Professor Theodore D. A. Cockerell; "The Future of Economic Entomology," Professor H. T. Fernald; "The Instinct of Feigning Death," Professor S. J. Holmes. For March: "America's Intellectual Product," Professor Arthur Gordon Webster; "A Grain of Truth in the Bushel of Christian Science Chaff," Charles Clarence Batchelder; "A Visit to the Hanchow Bore," Dr. Charles Keyser Edmunds; "Railway Accidents and the Color Sense," Professor George M. Stratton; "The Influence of Technical Schools," Professor John J. Stevenson; "Kelvin in the Sixties," Professor W. E. Ayrton; "Man's Educational Reconstruction of Nature," Professor Edgar James Swift.

Scientific American Supplement for February 22: "Steel Making by Electricity, a Review of Modern Processes," "Sound Waves and their Work," by Day A. Willey. February 29: "Medicinal Properties of Plants," Dr. W. E. Everette. March 7: "Decorative Insects; Bugs that Serve as Adornments."

THE AMERICAN FEDERATION OF TEACHERS OF THE MATHEMATICAL AND THE NATURAL SCIENCES.

A meeting of delegates of associations interested in the formation of an American Federation of Teachers of the Mathmatical and the Natural Sciences was held in Chicago on January 1, 1908. There were present 23 representatives of 13 associations, as follows: Association of Physics Teachers of Washington City, 1; Association of Mathematics Teachers of New England, 1; Central Association of Science and Mathematics Teachers, 6; Colorado Mathematical Society, 1; Connecticut Association of Science Teachers, 1; Indiana State Science Teachers Association, 2; Kansas State Association, Mathematics Section, 1; Michigan Schoolmasters' Club, Mathematics, Physics, and Biology Sections, 3; Nebraska State Association, Physical Science Section, 2; New England Association of Chemistry Teachers, 2; New York State Science Teachers Association, 1; North Dakota Association of Science Teachers, 1; Northeastern Ohio Association of Science and Mathematics Teachers, 1.

In the absence of the Chairman, the meeting was called to order by the secretary, and Professor F. S. Woods of Boston was elected chairman pro-tem.

The minutes of the last meeting having been printed and distributed, their reading was dispensed with.

The report of the executive committee was then read and accepted. The recommendations in that report were taken up for consideration. In accordance with those recommendations, the articles of federation were slightly amended, passed seriatim, and then passed as a whole in the following form:

1. The associations of the teachers of science and of mathematics shall form as soon as possible an organization to be known as the American Federation of Teachers of the Mathematical and the Natural Sciences.

2. Associations only are eligible to membership in the Federation. Any association whose purpose is the study of the problems of science and mathematics teaching, and whose number of active members is twenty-five or more, shall be eligible to membership.

3. By joining the Federation, an association in no way loses its individuality, nor its right to conduct its work in its own territory in its own way.

4. An association joins the Federation by appointing delegates to a body to be known as the Council of the American Federation, by having its delegates accepted by the Council, and by paying to the treasurer of the Council the dues as specified in number 6.

5. Each association shall have one delegate for every fifty members; but each association shall have at least one delegate.

6. Each association shall pay to the Council annual dues of five cents per member of the association, in order to defray the necessary expenses of correspondence by the Council. The fiscal year shall date from Sept. 1 each year. The Council is authorized to increase the per

capita assessment of associations not to exceed ten cents if found necessary.

7. The delegates shall hold office for three years and be eligible for reëlection. At the time of its organization, the Council shall divide its members into three classes, one of which shall retire at the end of each year. The Council shall notify each association each year how many delegates are to be elected by it then.

8. The Council shall elect its own officers, namely, president and secretary-treasurer, who shall hold office for one year and be twice eligible for reëlection. These officers, together with three others elected annually, shall constitute the executive committee of the Council.

9. The work of the Council shall be carried on mainly by correspondence, but an annual meeting shall be held, at such time and place as the executive committee shall select. At any meeting the members of the Council who are present shall constitute a quorum for the transaction of business; but if less than one-third of the members are present, all business so transacted shall be ratified by correspondence.

10. The duties of the Council shall consist in devising methods by which the associations may work together for the betterment of the teaching of science and of mathematics. The Council shall act toward each association in a purely advisory capacity, no association being bound by the terms of the federation to follow the suggestions of the Council if it does not wish to do so.

11. All publications issued in the name of the Federation shall be approved and authorized by the executive committee.

12. The Council shall publish each year a detailed statement of receipts and expenditures, and a brief outline of the work done during the fiscal year. This statement shall be sent annually to the officers of each association in the Federation.

On recommendation of the executive committee it was voted that, pending the report of the committee on policy as to publication, the executive committee be authorized to print the reports and documents of the Federation in such of the established journals as it may select.

At the meeting in 1906 in New York no officers were elected, but only an executive committee appointed. The articles of federation having now been formally approved by the meeting, the following officers were elected for the year 1908:

President, H. W. Tyler, Association of Mathematics Teachers of New England.

Secretary-treasurer, C. R. Mann, Central Association of Science and Mathematics Teachers.

Additional members of the executive committee: R. E. Dodge, New York State Science Teachers Association; F. N. Peters, Missouri Society of Teachers of Mathematics and Science; J. T. Rorer, Association of Mathematics Teachers of the Middle States and Maryland.

It was announced that the application of the Federation for affiliation with the American Association for the Advancement of Science had been approved by that body, and that this affiliation entitled the Federation to elect a representative to the Council of that body. On nomination duly seconded, the President of the Federation, Professor

H. W. Tyler, was elected as the representative of the Federation to the Council of the American Association for the Advancement of Science.

The questions: What can be accomplished by the Federation that cannot be accomplished by existing machinery? and, What does an association gain by joining the Federation? were raised and discussed at length. Instead of trying to reproduce this discussion, the executive committee is preparing a statement of the purposes and proposed policy of the Federation, and this will be issued in the near future.

The meeting adjourned, subject to the call of the executive committee.

C. R. MANN, Secretary.

BIOLOGY AT THE WOODS HOLL LABORATORY.

BY GEORGE T. MOORE,

Marine Biological Laboratory.

Next summer the Marine Biological Laboratory at Woods Holl, Mass., will enter upon its twenty-first session. While during a score of years hundreds of students have become familiar with the character of the work done there, it may be worth while to give a brief account of the organization and advantages offered at what has been properly termed the leading marine laboratory of the country.

Although the laboratory at Woods Holl was not opened until 1888, it is justly considered to be the direct descendant of that first summer school of biology founded by Agassiz at Penikese fifteen years before. Indeed an unsuccessful attempt was made immediately after the closing of the Penikese laboratory to continue at Woods Holl the work so splendidly inaugurated by Agassiz. This effort failing, the germ of Agassiz' summer school was kept alive by the Woman's Educational Association of Boston, who with the Boston Natural History Society made several attempts to maintain a session of summer biological study. The natural advantages of Woods Holl finally resulted in definitely establishing the laboratory at that point, and subsequent years have abundantly proved the wisdom of the choice. The credit of discovering such an ideal location for a marine laboratory is due to Prof. Baird, who, while U. S. Fish Commissioner, made a most careful survey of the entire Atlantic coast in order to locate the most suitable spot at which to establish a station for the Fish Commission. Woods Holl was so evidently superior to any other place available for such a purpose, that a marine station and laboratory of this important branch of the Government service has been maintained here since 1881.

Woods Holl is situated on the north shore of Vineyard Sound at the entrance of Buzzard's Bay. With a flora and fauna rich in all the forms which are necessary for thorough biological training, a climate well adapted for summer study, and freedom from the inconveniences and distractions of a fashionable resort, it would seem that the only additional requisite for making a most successful summer school was the presence of those capable of making use of such advantages. In the past, earnest workers and staff have contributed their full

share to the success of the Marine Biological Laboratory, and it is believed that the future will see even greater results from the coöperation of those who are fortunate enough to do work at Woods Holl. An examination of the courses offered and the staff of instructors will show how abundant are the opportunities for biological work.

The following list is taken from the preliminary announcement which recently appeared in SCIENCE:

It is expected that the research staffs in zoölogy and physiology will be substantially the same as in 1907, viz:

ZOOLOGY.

E. G. Conklin, professor of zoölogy, University of Pennsylvania.

C. W. Hargitt, professor of zoölogy, Syracuse University.

George Leferve, professor of zoölogy, University of Missouri.

Warren H. Lewis, associate professor of anatomy, Johns Hopkins University.

Frank R. Lillie, professor of embryology, University of Chicago.

T. H. Morgan, professor of experimental zoölogy, Columbia University.

C. O. Whitman, professor of zoölogy, University of Chicago.

E. B. Wilson, professor of zoölogy, Columbia University.

PHYSIOLOGY.

Albert P. Mathews, professor of physiological chemistry, University of Chicago.

E. P. Lyon, professor of physiology, University of St. Louis.

Ida H. Hyde, professor of physiology, University of Kansas.

R. S. Lillie, instructor of comparative physiology, University of Pennsylvania.

A. J. Carlson, assistant professor of physiology, University of Chicago.

Edward G. Spaulding, assistant professor of philosophy, Princeton University.

Oliver P. Terry, instructor in physiology, Purdue University.

Horatio H. Newman, instructor in Zoölogy, University of Michigan.

BOTANY.

The research staff in botany for 1908 will include the following:

Assistant Professor C. J. Chamberlain, University of Chicago.

B. M. Duggar, professor of plant physiology, Cornell University.

Henry Kraemer, professor of botany, Philadelphia College of Pharmacy.

George T. Moore, Water Mill, New York.

Erwin F. Smith, in charge of Laboratory of Plant Pathology, United States Department of Agriculture.

Hermann von Schrenk, pathologist, Missouri Botanical Garden.

M. B. Thomas, professor of botany, Wabash College.

A limited number of private rooms is available for other investigators in botany. Applications for use of these rooms should be made to Dr. George T. Moore, Water Mill, New York.

Subjects for investigation in zoölogy, physiology, or botany will be assigned to those whose previous training qualifies them to begin research. The student may select his teacher in investigation, subject to the approval of the latter.

II. INSTRUCTION.—The courses of instruction are six weeks each, including about four weeks in July and two in August. Each course requires the full time of a student. They are so graded that the student may supplement his college instruction by courses leading up to research, or he may take the more elementary courses in zoölogy or general morphology of plants. Credit for courses taken in the Marine Biological Laboratory is generally given by colleges and universities and also by boards of education of various cities, on certificate of the instructor in charge. It has been decided to add two courses to those given in recent years, viz., a course in embryology and one in general morphology of plants.

1. Zoölogical instruction, season of 1908, will be in charge of Carlton C. Curtis, assistant professor of zoölogy, University of Missouri, assisted by Paul M. Rea, professor of biology, College of Charleston, and director of the Charleston Museum; Max Morse, tutor in Natural History, College of the City of New York; Lawrence E. Griffin, professor of biology, Missouri Valley College; Edward E. Wildman, instructor in biology, Central High School, Philadelphia, and John W. Scott, Westport High School, Kansas City.

Although Dr. L. L. Woodruff, instructor in biology, Yale University, is leaving the staff in zoölogy for that in embryology, he has consented to give the lectures on protozoa in 1908.

The conduct of the work in this subject will not differ substantially from the plan which has proved successful in recent years. Lectures and laboratory work are supplemented by extensive collecting trips, during which the student has opportunity to observe the methods of marine collecting and to study a wide range of marine forms in their natural surroundings.

2. The course in embryology will be in charge of Professor Gilman A. Drew of the University of Maine, Orono, Maine, assisted by Dr. L. L. Woodruff, instructor in biology, Yale University, and Dr. W. E. Kellicott, professor of biology in the Woman's College of Baltimore.

It is the aim of this course to meet the needs of those who desire to get an insight into fundamental problems, and to serve as a basis for those who desire to begin independent investigations. It will supplement the usual college course in embryology, laying special weight on questions of general importance that can be best approached by the study of the living marine material.

The work will include the study of organization, maturation, and fertilization in the egg, the early development, types of gastrulation, and the effects of different conditions on development. The advantage of following the actual process of development in the living egg, instead of comparing a few preserved stages of development, cannot be overestimated.

The course will be accompanied by lectures delivered by members of the staff and other investigators working at the laboratory. For the course in embryology, the course in zoölogy or its equivalent is a prerequisite.

3. The course in comparative physiology will be in charge of members of the same staff as in 1907, as given above.

The course will include study of the physico-chemical constitution of protoplasm, physics of cell-division and contractility, phenomena of inheritance from a physico-chemical standpoint, the physical basis of conduct, comparative physiology of the heart and circulation, and comparative physiology of the central nervous system. Lectures will be given by members of the staff and others.

IV. The following courses will be offered in botany:

1. Morphology and Taxonomy of the Algæ conducted by Dr. George T. Moore, assisted by George R. Lyman, assistant professor of botany, Dartmouth College, and R. R. Gates, fellow in botany, University of Chicago.

A general course upon the algæ, designed to give a knowledge of the habits, structures, and life histories of this group.

2. Morphology and Taxonomy of the Fungi, conducted by Dr. Lyman and Mr. Gates. A general course upon the fungi similar to that outlined for the algæ.

3. General Morphology of Plants.

No prerequisites are stated for this course which will be conducted by Professor C. J. Chamberlain of the University of Chicago with assistants: an outline of the plant kingdom, based upon the study of selected types. Emphasis will be laid upon the facts connected with the evolution of plants, such as the origin of sex, alternation of generations, heterospory, origin of the flower, origin of the seed, etc. The general relationships and classification of the flower groups will also be discussed, including the history of the groups as developed by paleobotany.

Mr. W. R. Maxon of the United States National Museum will act as collector in botany. The usual lectures and seminars will be offered.

Nothing could so emphasize the national character of the Marine Biological Laboratory and its independent spirit as this list of workers, who, for the most part, have been associated with the institution from the first. The Trustees, who have the more direct management of the Laboratory, consist of Professors from some eighteen colleges and universities, in addition to a half dozen business men who are on the board.

REPORT OF MEETINGS.

Washington Association of Mathematics Teachers.

The regular meeting of the Association of the Teachers in Mathematics in Washington was held on Jan. 1, 1908 in Seattle, President J. C. Keith, Seattle, presiding.

The following papers were read and discussed:

Desiderata in Modern Courses in Plane Trigonometry, Prof. Robert E. Moritz, University of Washington.

The Mathematical Tripod of Secondary Schools, Prof. J. H. Morgan, Ellensburg Normal School.

Discussion of Report of Committee on Algebra presented in SCHOOL SCIENCE AND MATHEMATICS for November, Miss Minnie A. Gibbons, Tacoma High School.

The officers for the succeeding year were elected as follows:

W. S. Malone, Tacoma High School, Pres.

Geo. De Velbis, Seattle High School, Vice-Pres.

Minnie A. Gibbons, Tacoma High School, Sec.-Treas.

Jacksonville Center.

The Jacksonville, Ill. Center, C. A. S. and M. T. held an interesting meeting January 17th. The program was a symposium of reports from various association meetings held recently. Dr. Harris of Illinois College spoke concerning the sessions of the American Association for the Advancement of Science held during the holidays in Chicago. He urged on the profession their attendance upon such meetings both for the quickening of mentality and the awakening of friendship.

Professors W. O. Beal and I. S. Smith of Illinois College and Miss I. S. Keuchler of the Jacksonville High School gave reports from the St. Louis meeting of C. A. of S. and M. T., discussing the general sessions and the sessions of the mathematical and biological sections. Correlation along mathematical lines, and emphasis on the ecological side of biology were made prominent.

Professor I. S. Smith of Illinois College told of the meeting at Springfield, Dec. 7th, for the founding of the Illinois State Academy of Science. Mr. F. J. Meek of the Jacksonville High School gave a report of the State Teachers' Association at Springfield during the holidays, dwelling particularly on the strong address of Rabbi Hirsch of Chicago. The reports were interesting and timely and the inspiration of such a meeting can but quicken our work in Jacksonville.

Kansas Association of Mathematics Teachers.

Article II. Object: 1. The improvement of the teaching of mathematics in the schools of Kansas.

2. The promotion of the best possible correlation of mathematical subjects with each other and with the other subjects in the curriculum.

3. The establishment of cordial and helpful relations among mathematics teachers.

The Kansas Association of Mathematics Teachers in the four years of its existence never came nearer realizing the purpose of its organization than at its last meeting in Topeka, Dec. 26 and 27, 1907.

When President C. A. Wagner of Hutchinson announced the first number on the program he faced a large crowd of representative teachers from Kansas colleges, high schools, normal and common schools who listened with great interest and on their own assertion with much profit to a program arranged for Thursday with reference to difficult points in the teaching of algebra.

Prof. C. H. Ashton of the University of Kansas, co-author of the state text on algebra, talked on "Factoring," giving his opinion as to the value of the subject, best order and method of development, which cases to emphasize, omit, etc., answering many questions as to the text.

The next topic was taken by Miss Effie Graham of the Topeka High School. She urged the necessity of a more general definition at the start, the understanding of the history of the growth of exponents, their meaning as well as their use, and that negative exponents be used rather than gotten rid of.

Prof. Ashton gave the report of the committee appointed to eliminate certain subjects from the arithmetic text.

Miss Emma Hyde of the Iola High School distributed mimeograph copies of "The First Twelve Lessons in Demonstrational Geometry," preceding her talk on the subject. These lessons were original with Miss Hyde, and were used in her classes as an introduction to demonstrational work.

Mr. R. M. Winger, principal of the Holton High School, spoke on "The First Twelve Lessons in Demonstrational Geometry." He gave the order and method by which he taught the first propositions in the state text.

Friday P. M. the Association had the pleasure of listening to Dr. Myers of the University of Chicago in an address on "An Experiment in Teaching of High School Mathematics." This was, in the main, the history of the development of a text called "First Year Mathematics for Secondary Schools," used now in the University High School at Chicago, the first volume of a series "designed to do away with the present artificial division of the mathematical course and to relate the study to the pupil's whole existence."

The officers elected for the coming year are: Prof. W. A. Harshbarger, Topeka, president; Prin. R. E. Haresock, Pittsburg, vice-president; Miss Effie Graham, Topeka, secretary-treasurer, who was also appointed to represent the Association at the meeting of the American Federation of Mathematics and Science Teachers, held in Chicago, Jan. 1 and 2, 1908.

A full report of the papers and discussions, including the report of Dr. Myers's address, will be printed and furnished the members of the Association.

A dinner at the Copeland Hotel was arranged by the Association, affording the teachers an opportunity to meet Dr. Myers.

THE HIGHEST HONOR.

Webster's International Dictionary, recognized by the Courts, the Schools, and the Press, as the One Great Standard Authority of the English-speaking world justly deserves the honor of being the Only dictionary to receive the Gold Medal, the highest award of merit from the Jamestown Exposition. Awards of the highest class were also received from the St. Louis, and Portland Expositions, and also the International Exhibition held at Christchurch, New Zealand, in 1906-7.

If you haven't the International Dictionary in your home why not address the publishers, G. & C. Merriam Co. of Springfield, Mass. for specimen pages, style of binding, etc.? By mentioning this paper you will receive free, a most useful set of colored maps. See advertisement elsewhere in these columns.

BOOKS RECEIVED.

Problems and Questions on Algebra, compiled from Board, Case, Cornell, Harvard, M. I. T., Princeton, Regents, Sheffield, and Yale, by Franklin Turner Jones. University School, Cleveland, Ohio. Price, 30c.

Problems and Questions on Chemistry, compiled from Board, Case, Cornell, Harvard, Princeton, Regents, and Sheffield, with hints on the solution of problems and a list of incomplete equations by Franklin Turner Jones. University School, Cleveland, Ohio. Second Edition, enlarged. Price, 30c.

A Scrap-Book of Elementary Mathematics by William F. White, Ph.D., State Normal School, New Paltz, New York. The Open Court Publishing Co., Chicago.

A Text-Book in Physics for Secondary Schools, by Wm. M. Mumper, State Normal School, Trenton, N. J. Pp. 411. 1907. American Book Company.

Physiography for High Schools, by Rollin D. Salisbury, Head of the Department of Geography, University of Chicago. Pp. 531. 1908. Henry Holt & Co.

Graphic Algebra by Arthur Schultze, Head of the Department of Mathematics, High School of Commerce, New York. Pp. 93. 1908. The Macmillan Co., New York. Price, 80 cents net.

BOOK REVIEWS.

Financial Independence, Through Saving and the Right Use of Money, with 100 illustrations by Harry Waters Armstrong. Two volumes, including also Home Ledger and Accountant, and two Pocket Accountant Cash Books, the producer's and the housewife's. 8vo, pp. 637. Perry Publishing Association. Per set, boxed, net $5.00; postage, 40c.

The central thought of this work is to create within the minds of young wage earners, especially, the idea of spending less than they earn. Anyone of ordinary intelligence reading these volumes cannot help becoming thoroughly impressed with the absolute necessity of putting into practice the heart thought of the work.

The books do not simply tell one what to do in order to save part of one's wages, but they tell *how* to do it in such a manner and style that the reader must be impressed with the importance of saving while in his prime in order to have a competence in later years.

The books are readable and interesting, driving home their truths by illustrations from life. Every wage-earner and bread-winner should read the work. If the gospel preached here is observed and practiced by the reader, wage earning will become more easy in the thought that one knows how to save.

Advice and the best methods of saving one's earnings by investment is given. The books deserve a very wide circulation. C. H. S.

Paradoxes of Nature and Science, by W. Hampson. New York: E. P. Dutton & Company. Pp. 304. $1.50.

"Nature is a great conjurer. With many of her tricks we are so familiar that they do not astonish us * * *. Equally interesting puzzles occur in the course of experimental work in the laboratory; but in this book the choice will be limited * * * to such experiments as can be readily performed, with very simple apparatus, at home."

The author more than keeps his word by accompanying the experiments with ingenious and easily understood explanations of the paradoxes themselves. He harmonizes theory of limits and continuity of time and space by the interesting puzzle of "Achilles and the Tortoise," and succeeds in making the former win, as he must, in spite of the mathematical proof that he cannot.

The paradoxes discussed are divided into four main parts—(1) Mechanical, (2) Of Physical State, (3) Chemical, (4) Physiological—which are again divided and subdivided. It is unfortunate that space does not allow the reproduction of the entire table of contents. Among the particular paradoxes are found: When a train is going 60 miles an hour what part of it is moving backward? A sailing boat which moves more swiftly than the wind which is driving it? Boomerangs; Water boiled by cold instead of fire; Dipping the hand into molten lead; The radium clock; Water a source of fire; The Philosopher's Stone; Pumps without Pistons, etc., etc. In all sixty paradoxes are described and explained.

The explanations are uniformly clear and easily understood, though, naturally, some are more interesting than others. As a book to put into the hands of high school students, it has few equals. No other single book covers the field in such a complete and satisfactory way, nor offers such stimulus to the kind of thought that high school science seeks to encourage. Most boys and many girls would be enthusiastic over it. F. T. J.

Practical Physiography. By H. W. Fairbanks. 23 chapters, 572 pages, and 403 illustrations. Allyn, Bacon & Co.

This text presents much new material from the Pacific coast that will be greatly appreciated by the western teacher. The book is divided into Part I entitled "The General Physiographic Processes," and Part II, "The Physiography of the United States." Part I is a review of the general geological processes, it is well written and the many illustrations intensify the statements of the text. The study of physiography is always benefited by a general view of the geological processes, after which the pupils are better able to understand the land features and comprehend their origin. Chapter I, "The Earth," although skillfully written, lacks logical sequence and embraces topics which are only vaguely related. The discussion of the original condition of the earth should come earlier, while the question at the end of the chapter is rather lame. There is much in chapter V on Minerals and Rocks that might be considered too extensive, but it is practical and interesting. Terms like ryolite, andesiye, and syenite are a trifle too heavy for the

class of pupils that will use the book. The largest part of this chapter treating of the economic importance is too meagre, it could be enlarged with considerable profit.

In the presentation of the Geographical Cycle (Chapter VII) the attempt has been made to tell it, rather than to unfold a systematic plan of land development, it is the most unsatisfactory work in the text. The term "young" implies more in a geographical cycle than "new" which the text uses.

Part II is an application of the geological processes to the various regions of the United States. In the discussion of plains, the treatment is a simple classification. The term coastal is more familiar and fully as satisfactory as that of marine plain used by the text. The book has not made any improvement by omitting a vigorous description of the various types and their modifications.

Chapter XIII is a step in advance of most of the modern texts in their treatment of mountains. Some objections might be made to the use of the terms Sonoran, Boral, etc.

The chapters devoted to the atmosphere are not up to the general standard of the other parts of the text. Placing the suggestive exercises and questions in a miscellaneous manner through the text matter does no give as satisfactory results as the use of a regular class book with a well-planned laboratory manual. The book is profusely illustrated and the plates are generally very instructive. This book is sure to awaken much interest and it will be welcomed because of its wealth of teachable material and its clear presentation. W. M. GREGORY.

Evolution and Animal Life. Jordan, David Starr and Kellogg, Vernon Lyman. 489 pages, 298 figures. D. Appleton and Company, New York.

The literature of general evolution has received an important addition in the form of a book entitled "Evolution and Animal Life." Each of the authors has been a welcome contributor to the subject before, but the present work is made up mainly of the materials used by them in a course of elementary lectures in the university. Little of the data upon which the book is built is new, but some of the inferences are new and some will not always meet full approval. That the authors do not expect all readers to agree in all their interpretations is shown by the following quotation from the Prefatory Note: "We cannot talk long without saying something others do not believe. Others cannot talk long without saying something we do not believe. We wish you to accept no view of ours unless you reach it through your own investigation. What we hope for is to have you think of these things and find out for yourselves." This is an admirable basis for beginning consideration of topics so difficult as some of these, and although at places in the text the statement of the authors appear somewhat dogmatic it is to be presumed that they wish us to keep in mind their prefatory admonition.

While it is not possible within the limits of a review adequately to describe the scope of this book, its contents may be indicated briefly.

The first few chapters lay the general basis of work by defining evolution, pointing out the variety and unity in life, discussing its physical basis and the factors involved in the working of evolution. These factors, as variation, natural and artificial selection, overproduction, heredity, isolation, mutation and adaptation, each becomes later the subject for one or more entire chapters. Probably the chapters on which most critical attention will be turned are those on "Variation and Mutation," "Heredity," and "Inheritance of Acquired Characters." In all controversies concerning evolution no one questions the facts of variation and heredity, but the extent to which variations may go without affecting the conception of the type producing the variation and the extent and amount of influence heredity really does exert—these are the points of great difference of opinion. The authors attempt to discern upon what the various "opinions" rest, and to give us their conclusions therefrom. Unfortunately there is so much unknown that not a little current discussion on the above questions is made up of "opinion" rather than knowledge. It is of interest to note that the authors, while presenting a liberal statement of the theory of origin of species by mutation as described by De Vries, do not give it the amount of credence accorded this theory by some recent writers. Concerning mutation, they say, "While saltation (mutation) remains as one of the probable sources of specific difference, the actual rôle of this process in nature is yet to be proved."

In the discussion of heredity an unusually large collection of data is presented. In the theories of heredity Mendel's law receives major attention, and while it is recognized that his "name will undoubtedly live forever in the annals of biological science," it is equally clearly pointed out that Mendel's laws of heredity cannot be made to apply to "all cases and categories of inheritance." In connection with the subject of inheritance of acquired characters many readers will be surprised at being told that "after some years of controversy, mostly theoretical, the discussion has been tacitly dropped by biologists generally." It is doubtless true that no positive evidence has been brought forward to prove the old claims for inheritance of acquired characters, but it is a subject not to be silenced by the incident of absence of evidence. The authors say, " * * * and yet perhaps most naturalists feel that the effects of extrinsic influences work their way into the species, although a mechanism by which this might be accomplished is as yet unknown to us."

The entire book of twenty-one chapters is thoroughly interesting, and especially so are those chapters upon "Geographical Distribution," "Reflexes, Instinct and Reason," and "Man's Place in Nature."

O. W. C.

LAST CALL!

In accordance with the new postal regulations this will be the last number sent to members of associations whose dues payable January 1, 1908, are still unpaid. Also to all other subscribers who are in arrears for four months or longer.

If you are one of these, please send any unpaid dues to the treasurer of your association, or RENEW YOUR SUBSCRIPTION AT ONCE, and save the inconvenience of missing any numbers of the magazine. DO IT NOW.